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NOLTR 62-219

TIMES FAX: AN UNDERWATER ACOUSTIC
RANGE REFERENCE

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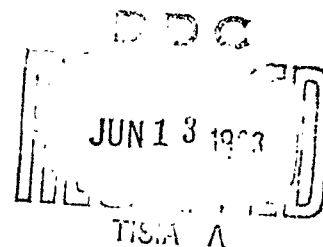
UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 62-219

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TIMES FAX: AN UNDERWATER ACOUSTIC
RANGE REFERENCE

Prepared by:
D. D. Woolston
and
E. A. Bitz

ABSTRACT: This report describes a sonar range reference
system, referred to as the Times Fax System, for deter-
mining the relative range between two submarines. Times
Fax ranging capabilities vary with submarine self noise
and sonar conditions. Considering sea state noise only,
Times Fax has a ranging capability of 28 kiloyards to 10
kiloyards for Sea States 2 and 6, respectively.

The various subsystems of the integrated Times Fax System
are discussed in detail. However, the subsystems not com-
mercially available are emphasized.

This system has been in use on submarines since 1959. The
system has been used for sonar and torpedo evaluation
programs.
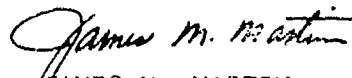
PUBLISHED MAY 1963

TIMES FAX: AN UNDERWATER ACOUSTIC RANGE REFERENCE SYSTEM

The Times Fax ranging system is a one-way pulse, chronometer-
controlled ranging system. The system has been in use on
submarines since 1959.

Information is given in this report that describes the Times
Fax System in respect to theory, recording and data pro-
cessing instrumentation, and system fabrication. System
fabrication does not include layout procedure.

                         R. E. ODENING
                         Captain, USN
                         Commander

                         James M. Martin

                         JAMES M. MARTIN
                         By direction

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS

References

(a) Journal of Underwater Acoustics Report C-83511; A 1 kc Transducer Element for a Long-Range Search Sonar Array

(b) Undersea Technology Technical Magazine, November-December 1962; Controlled Rectifier Sonar Transmitter

TIMES FAX: AN UNDERWATER ACOUSTIC RANGE
REFERENCE SYSTEM

INTRODUCTION

1.   The need for range reference information at sea
became apparent during the evaluation of sonar and fire
control systems.   The only available range references
that could be conveniently used at sea were radar and
the underwater telephone (UQC).   Radar limited the range
to the target to line of sight operations.   Also, the
tracking and target ships or submarines were limited to
surface or periscope depth of operation.   UQC can be used
for range checks during submerged operations; however, it
is not accurate enough and requires excessive underwater
transmission time.

2.   The Times Fax System uses the water as the
transmission medium; therefore, the operating depth is
not limited.   Also, the human errors involved in using
UQC are eliminated.   Range information is read out
directly in yards on a time interval counter and subse-
quently printed or punched out on paper tape.

SYSTEM DESCRIPTION

3.   The Times Fax System is a chronometer controlled
range reference system.   A one-way 50 millisecond, under-
water acoustical pulse having a carrier frequency of 1066
cps is transmitted from a target vessel once per minute.
At the same instant this pulse is transmitted from the
target, a chronometer starts a time interval counter at
the receiving (tracking) location.   The transmitter and
receiver chronometers are synchronized with radio station
WWV or equivalent.

4.   The transmitted pulse stops a time interval
counter when it is received by the tracking ship's sonar.
The time interval counter uses an external time base
oscillator with its frequency set equivalent to the
velocity of sound in water in yards per second.

5.   The Times Fax System can be used as a range
reference for torpedo, sonar, and fire control evaluation
programs.   This system is subject to one-way sonar trans-
mission properties, since it uses the water as the trans-
mission medium.   Therefore, it is necessary to know the

average velocity of sound over the transmission path, as well as knowing the path. Thus far, Times Fax has only been used on submarines. An illustration showing a typical transmission of Times Fax is presented in Figure 1.

TIMES FAX SUBSYSTEMS

6. The Times Fax System consists of two subsystems referred to as a transmitting and a receiving system. The receiving subsystem requires a sonar platform for operation.

Transmitting System

7. A block diagram of the transmitting system is presented in Figure 2. The functions of the equipment in the various blocks are as follows:

a. <u>Projector (Transducer)</u> - The projector is a Naval Research Laboratory XEM-3B Electro-Mechanical transducer. It is electro-mechanically resonant at 1066 cps. The projector is described in detail in reference (a). A plastic fairing covers the transducer for protective purposes. Figures 3, 4, and 5 give transducer directivity patterns (polar graphs), transducer impedance plot, and a photographic layout of the transducer assembly.

b. <u>Frequency Standard (also used at the receiver)</u> - The Quartz Crystal Oscillator functions as a frequency standard for the chronometer (frequency divider-clock). General specifications are presented in Appendix A.

c. <u>Chronometer (also used at the receiver)</u> - The chronometer (frequency divider) when used in conjunction with the crystal oscillator is designed to provide an output pulse once per second. A modification was made to the chronometer to provide an output pulse for supplying reference ranges once per minute. The modification consisted of mounting a cam assembly to the one rpm planetary gear assembly. This cam assembly is used to actuate a microswitch located at the 60-second position on the chronometer. The cam assembly can be set to the exact time intervals with the second hand adjustment knob of the chronometer. An additional microswitch is located at the 45-second position on the receiver chronometer for stopping the time interval counter, if the Times Fax ping fails to stop it. General specifications are presented in Appendix B.

2
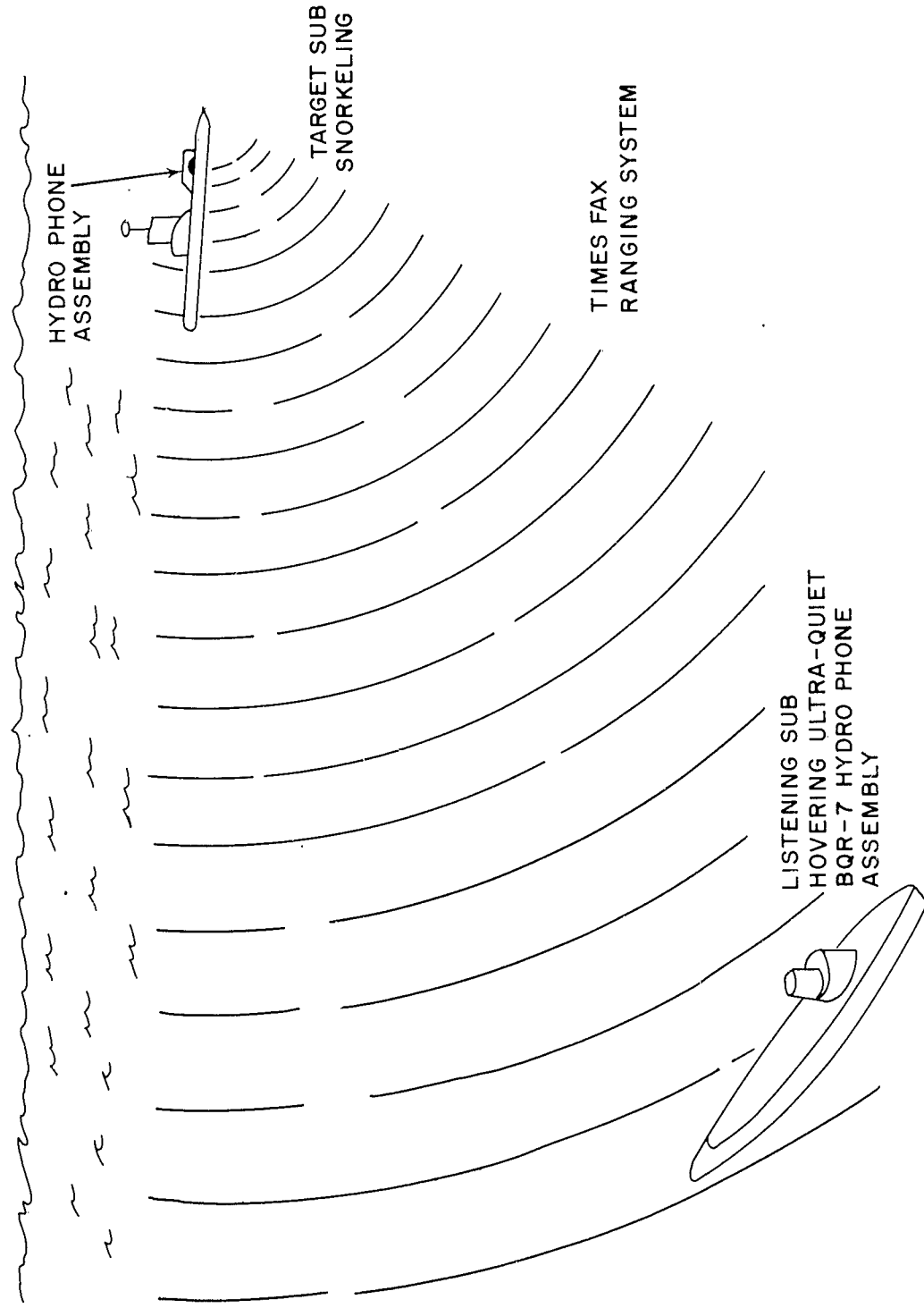
FIG. I TIMES FAX SYSTEM ILLUSTRATED

HYDRO PHONE ASSEMBLY

TARGET SUB SNORKELING

TIMES FAX RANGING SYSTEM

LISTENING SUB HOVERING ULTRA-QUIET BQR-7 HYDRO PHONE ASSEMBLY
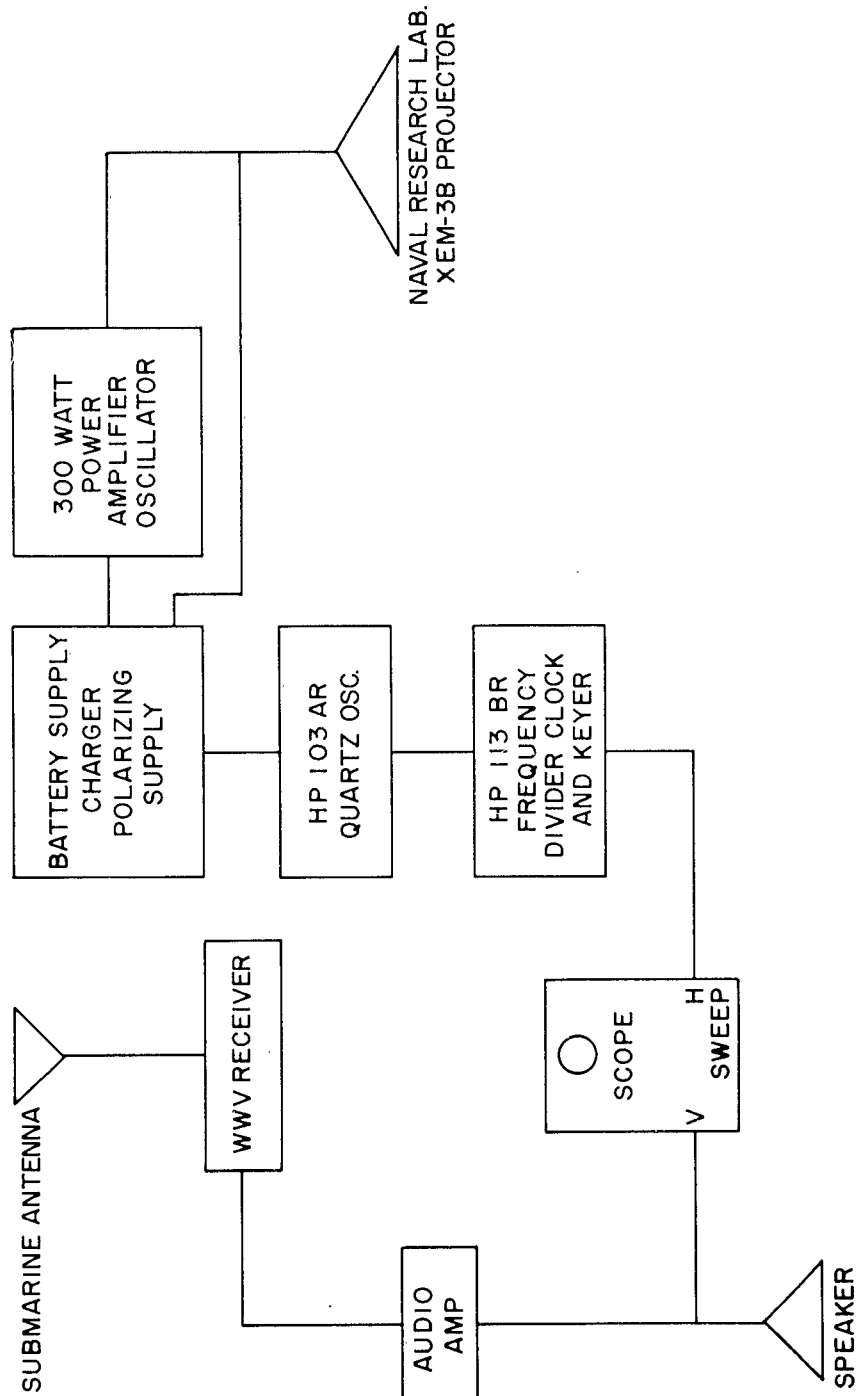
FIG. 2 BLOCK DIAGRAM OF THE TRANSMITTING SYSTEM
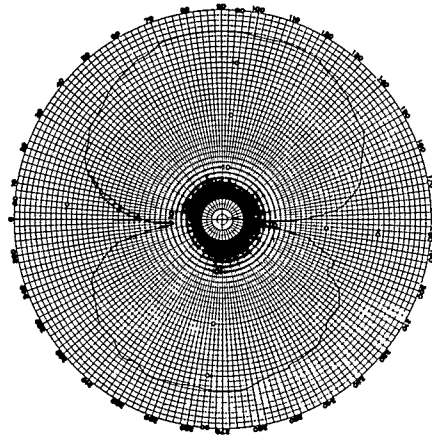
POLARIZING CURRENT   6.5 AMPS DC
TEST FREQUENCY   1041 CPS
LINE VOLTAGE   110 V RMS
MAXIMUM FIELD STRENGTH   91.2 db/μb AT 1 METER
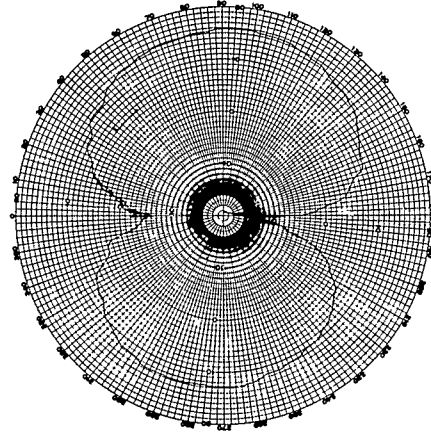
POLARIZING CURRENT   7.0 AMPS DC
TEST FREQUENCY   1041 CPS
LINE VOLTAGE   110 V RMS
MAXIMUM FIELD STRENGTH   91.2 db/μb AT 1 METER
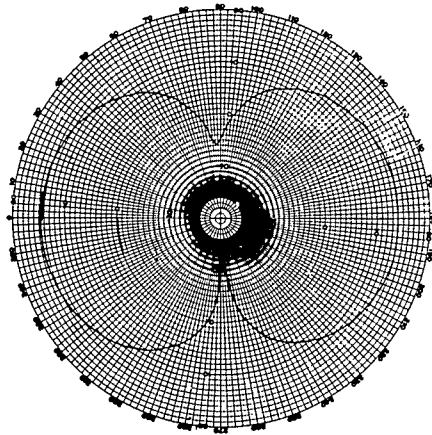
POLARIZING CURRENT   6.0 AMPS DC
TEST FREQUENCY   1041 CPS
LINE VOLTAGE   175 V RMS
MAXIMUM FIELD STRENGTH   89.7 db/μb AT 1 METER
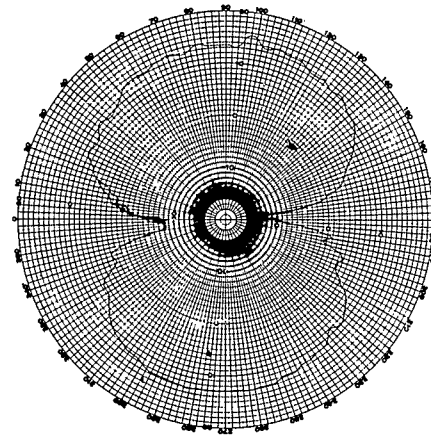
POLARIZING CURRENT   5.5 AMPS DC
TEST FREQUENCY   1041 CPS
LINE VOLTAGE   130 V RMS
MAXIMUM FIELD STRENGTH   84.75 db/μb AT 1 METER

FIG. 3 XEM-3B DIRECTIVITY PATTERNS (POLAR GRAPHS)

5
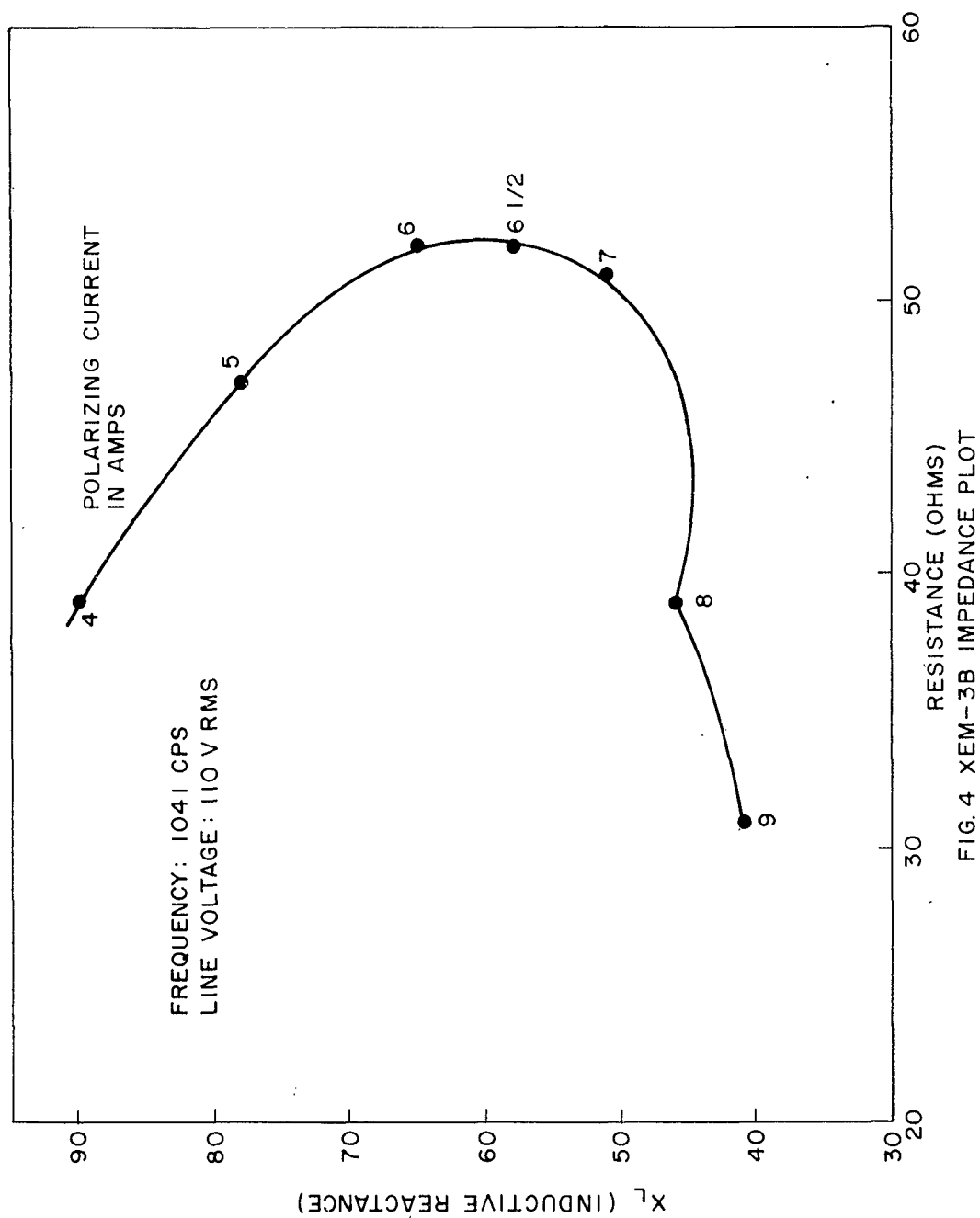
FIG. 4 XEM-3B IMPEDANCE PLOT
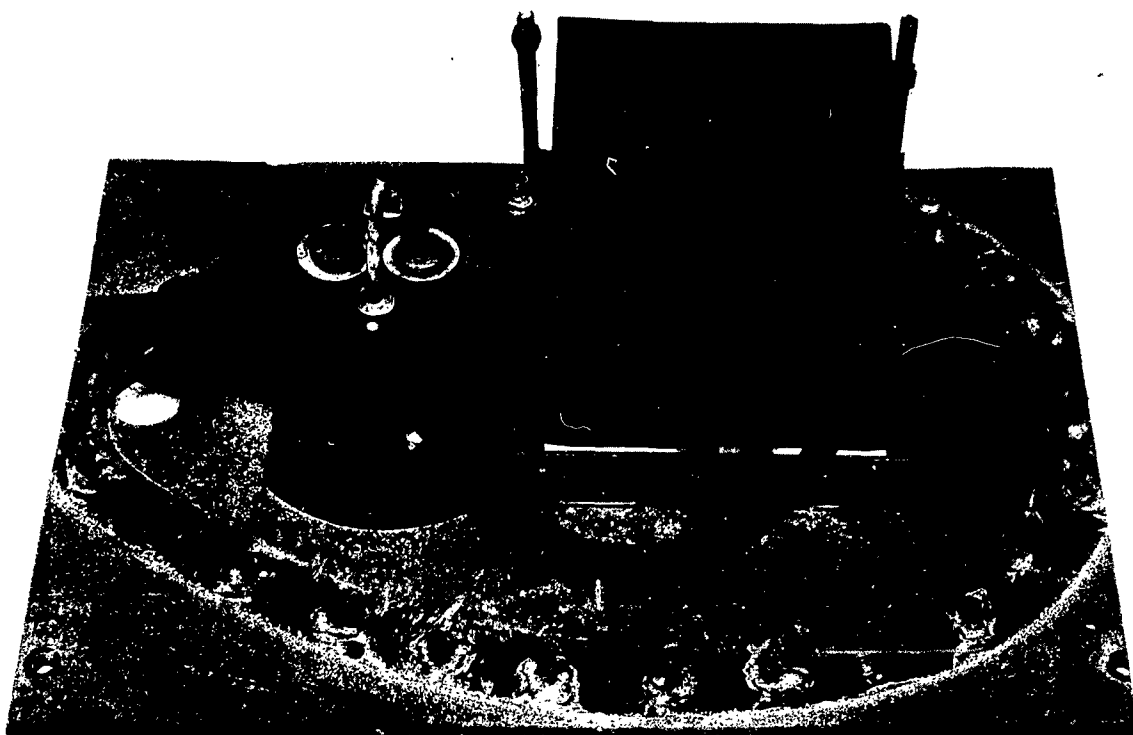
FIG. 5 XEM-3B ASSEMBLY

d. Battery Supply, Charger and Polarizing Supply -
One power supply provides power for the crystal oscillator
and chronometer combination. A similar power supply provides
polarizing current for the XEM-3B transducer and supplies
power for the 300-watt power amplifier-oscillator. The
circuit schematic is presented in Figure 6. Nickel cadmium
cells are used in the 28-volt battery supply.

e. 300-Watt Power Amplifier-Oscillator - The power
amplifier-oscillator assembly is comprised of five stages or
major parts: a keying stage, a tuned oscillator stage, a
buffer stage, a driver stage and an output amplifier stage.
An assembly circuit schematic is presented in Figure 7. The
aforementioned stages are accentuated by vertical dashed lines.
A complete description of the device is presented in Appendix
C. An equivalent power amplifier is now available commercially.
A recently designed power amplifier using SCR's (silicon con-
trolled rectifier) and the ship's 3 phase power is presented
in reference (b).

f. WWV Audio Amplifier - Speaker and Cathode Ray
Oscilloscope (CRO) - The ship's radio receiver is used to
receive radio station WWV's "Time Tick". The WWV signal
may be received at frequencies of 2.5, 5, 10, 15, 20 and
25 megacycles. WWV broadcasts a 5 millisecond pulse at
intervals of precisely one second. For identification pur-
poses, the 59th second pulse is omitted and the zero-second
pulse is followed by another pulse 100 milliseconds later.
The speaker-amplifier combination is used to listen to the
WWV time tick and time announcements. The chronometer with
the frequency standard is calibrated by referencing its
output to WWV. The calibration method employed compares
the position of the WWV signal on a cathode ray oscillo-
scope in respect to the leading edge of the beam. The CRO
horizontal sweep time is set for 10 milliseconds per centi-
meter and is triggered externally by the output from the
chronometer.

Receiving System

8. A block diagram of this system is presented in
Figure 8. The description of the items represented by the
blocks are as follows:

a. Ship's Sonar - The transmitted Times Fax pulse
is received by the tracking submarine's sonar. It is recom-
mended that the sonar system be placed in the automatic
tracking mode.

FIG 6 SCHEMATIC WIRING DIAGRAM OF BATTERY SUPPLY, CHARGER AND
POLARIZING SUPPLY COMBINATION

CONNECTION FOR ONE (1) TRANSDUCER

CONNECTION FOR TWO (2) TRANSDUCERS

POWER OUTPUT STAGE

DRIVER

BUFFER

1066 CPS OSCILLATOR

KEYER — INSULATE COLLECTOR FROM CHASSIS

TERMINAL STRIP ON TOP OF CHASSIS

28 V + B+VOLTAGE — MK 52 MODO BATTERY

TIMES FAX RELAY CONTACTS

PUSH BUTTON SWITCH ON FRONT PANEL

TEST POINTS ON FRONT PANEL

MICA CAPACITOR TUNE TO 1.066 KC APPROX. VALUE 0.005 UF

TRANSFORMER OUTPUT VOLTAGE	TRANSFORMER OUTPUT CONNECTIONS
50 V RMS	5 & 6
60 V RMS	6 & 3 ; 5 & 4 SHORTED
70 V RMS	8 & 7
80 V RMS	8 & 3 ; 7 & 4 SHORTED
120 V RMS	2 & 1
130 V RMS	4 & 1 ; 3 & 2 SHORTED
170 V RMS	6 & 1 ; 5 & 2 SHORTED
180 V RMS	6 & 1 ; 5 & 4 - 3 & 2 SHORTED
190 V RMS	8 & 1 ; 7 & 2 SHORTED
200 V RMS	8 & 1 ; 7 & 4 - 3 & 2 SHORTED
240 V RMS	8 & 1 ; 7 & 6 - 5 & 2 SHORTED
250 V RMS	8 & 1 ; 7 & 6 - 5 & 4 ; 3 & 2 SHORTED

	LOAD RESISTANCE
1.	8.33 Ω
2.	12.00 Ω
3.	16.33 Ω
4.	21.30 Ω
5.	48.00 Ω
6.	56.30 Ω
7.	96.00 Ω
8.	108.00 Ω
9.	120.00 Ω
10.	133.00 Ω
11.	192.00 Ω
12.	208.00 Ω

NOTES:

1. CORES FOR T1 & T2 ARE ARNOLD ENGINEERING CO., MOLYBDENUM PERMALLOY CORE PART NO. D-466281-3.

2. CORES FOR T3 & T4 ARE WESTINGHOUSE ELECTRIC CORP. HYPERSIL "C".

3. CORES FOR T5 ARE SQUARE STACKS OF ALLEGHENY LUDLUM STEEL CORE EI-75 LAMINATIONS.

FIG. 7 POWER AMPLIFIER

FIG. 8 BLOCK DIAGRAM OF THE RECEIVING SYSTEM

LOGIC PANEL POWER SUPPLY

LOGIC PANEL

DIGITAL CLOCK CMC

TALLY 420 TAPE PUNCHOUT

COUNTER CMC 727A TT$_1$ T$_1$ - T$_2$

COUNTER CMC 727A TIME INTERVAL STOP START

SCOPE V SWEEP H

NOL 1.066 KC 115 AC RECEIVER

SHIPS WWV RECEIVER

HP 113 BR FREQUENCY DIVIDER AND CLOCK

HP 103 AR QUARTZ OSC.

BATTERY SUPPLY BATTERY CHARGER TIME BASE OSC. AUDIO AMP & SPEAKER

BQR7
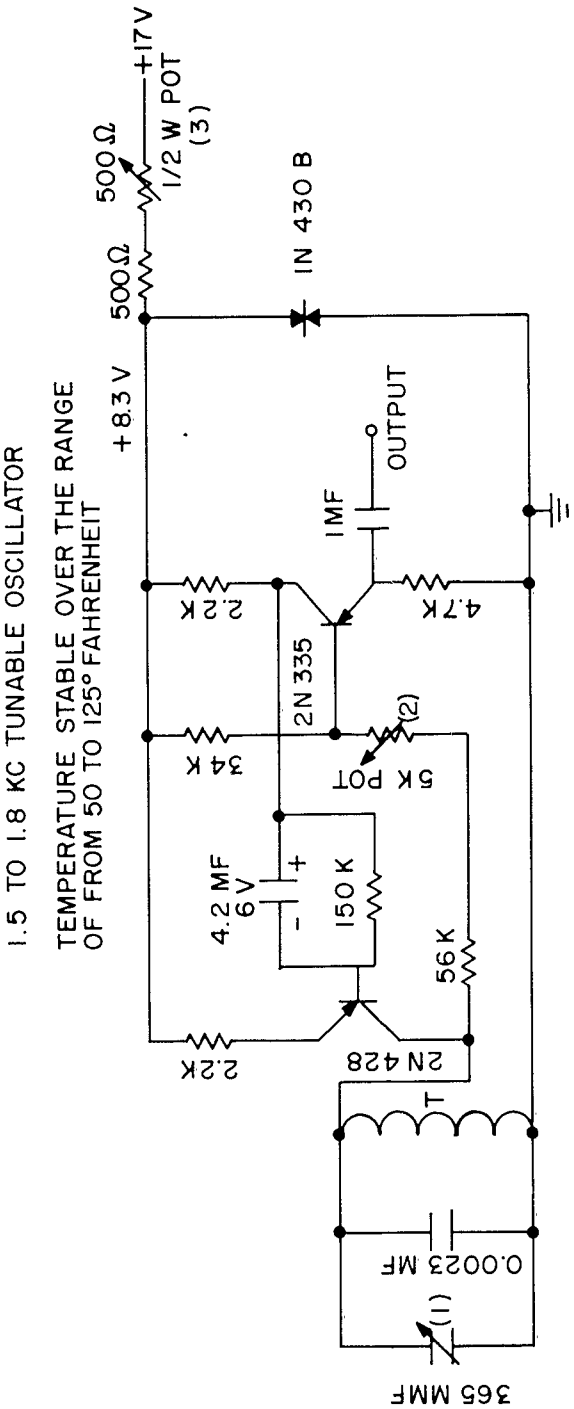
ANT

b. The Receiver - The function of the receiver
is to amplify the Times Fax signals as received by the
sonar and to recognize the signal pulse the instant it
arrives. When signal pulse recognition occurs, the
receiver generates a pulse to stop the time interval
counter. The receiver has a bandwidth of 50 cps centered
at 1066 cps in order to discriminate against unwanted
noise. The design of this receiver has undergone several
revisions, as experience indicated additional features were
desirable. These revisions consisted of add-on modifications
and, hence, the design details are something different than
would have resulted, if all of the desirable features were
incorporated into an initial design. Even so, the present
equipment will function in the required manner. Appendix D
provides a detailed description of this equipment and out-
lines some of the design and operational considerations.

c. Time Base Oscillator - The oscillator is tunable
over the frequency range of 1.5 to 1.8 kc. It is temperature
stable over the range of 50° to 125° F. A circuit schematic
of the oscillator is presented in Figure 9. The 2N335 tran-
sistor acts as a variable impedance and controls the collector
current through the 2N428 transistor. The 2N335 is a silicon
and the 2N428 is a germanium transistor. Temperature stability
of the oscillator is greatly enhanced by the 1N430b for con-
trolling power supply fluctuations and by using the 2N335 to
control the collector current of the 2N428.

d. Time Interval Counter - An electronic time
interval counter is used to measure the time interval from
the instant the pulse is transmitted until the instant the
pulse is received. The time base oscillator is used to
control the counting rate of the time interval counter.
The frequency of this oscillator is variable and was designed
to be adjustable from 1500 to 1800 cps. The exact frequency
is set to the velocity of sound in yards per second under
local conditions. This method of recording the signal transit
time gives the range in yards directly.

DATA RECORDING INSTRUMENTATION

9. The recording of the Times Fax range data can be
accomplished by a print-out or a logic punch-out recording
system. Either one of the two system will give satisfac-
tory results. However, the logic punch-out recording was
designed to be compatible with computer equipment. The
Times Fax range may also be read directly from the counter.
The "Logic" and the "Printer" systems are presented in

1.5 TO 1.8 KC TUNABLE OSCILLATOR

TEMPERATURE STABLE OVER THE RANGE
OF FROM 50 TO 125° FAHRENHEIT

FIG. 9 SCHEMATIC WIRING DIAGRAM OF TIME BASE OSCILLATOR

(1) PARALLEL PANEL VERNIER DIAL.
(2) ADJUST FOR MAXIMUM UNDISTORTED OUTPUT.
(3) ADJUST FOR 10 MA. ZENER CURRENT
T 5000 T #36 FORMVAR ON MOLYBDENUM PERMALLOY POWDER CORE NO. D-067032-4

Figures 10 and 11, respectively. All of the automatic recording equipment is available commercially. Integrated systems are also available commercially.

a. The Logic Punch-out System records the BCD (binary coded decimal) counter outputs on a paper tape punch after pre-BCD logic conditioning. This processing system is described in detail in Appendix E.

b. The Print-out Recording System uses a commercially available counter and printer. This system is the most basic of the two. Although the system is not directly compatible with computer equipment, the printed data may be manually punched on cards and these in turn can be used to write a magnetic tape for computation purposes.

c. As shown in Figure 11, the Print-out System accepts the BCD output from the counter directly and prints this information on paper. A stable oscillator circuit is still required as time intervals are being measured.

SUMMARY

10. The Times Fax ranging system has been compared with Surface Fire Control Radar. The results of these tests are presented in Figures 12 and 13. The range comparison, as shown in Figures 12 and 13 represent a maximum difference of 250 yards. Figure 14 shows a calculated curve of maximum range versus sea state for a (XEM-3B) projector sound intensity level of 90 db/μb at one meter. If the sea state is two, the graph shows the maximum obtainable range to be 28 kiloyards for a 14 db S/N ratio at the receiver input. This graph excludes the transient effect of the self noise which results in pseudo signals (stop signals) being sent to the time interval counter. In conclusion, the Times Fax System presented in this report was successfully tested prior to and in the evaluation of a sonar system. The Times Fax System is limited by sonar conditions and submarine self noise. Design efforts are being made to improve the Times Fax receiver.
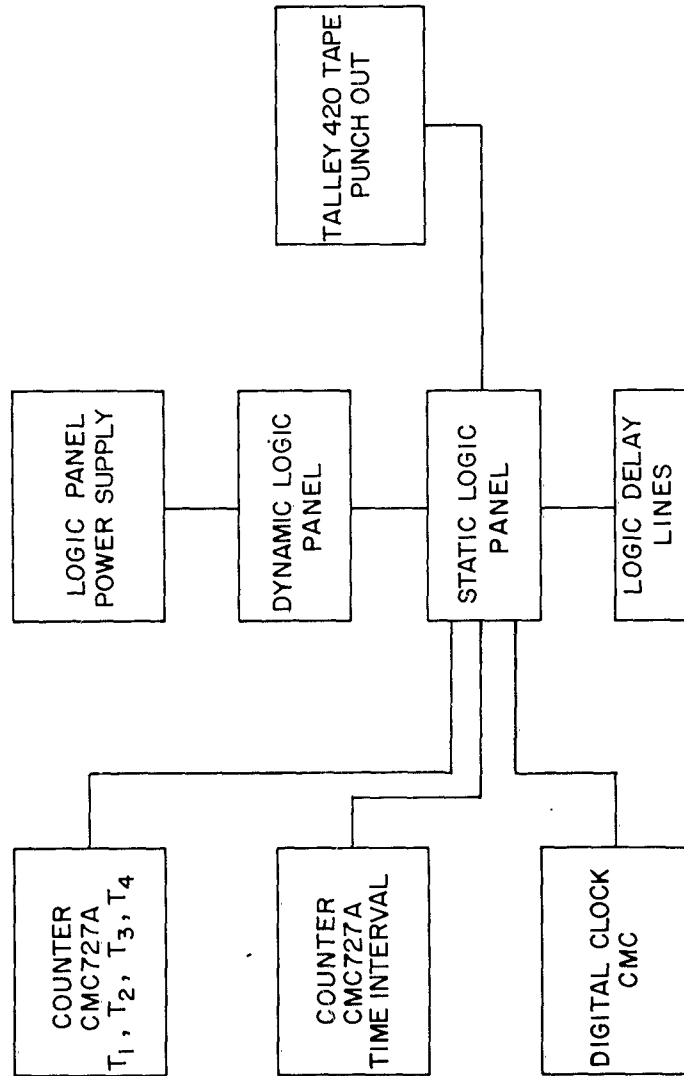
FIG. 10 BLOCK DIAGRAM OF LOGIC PUNCH-OUT SYSTEM
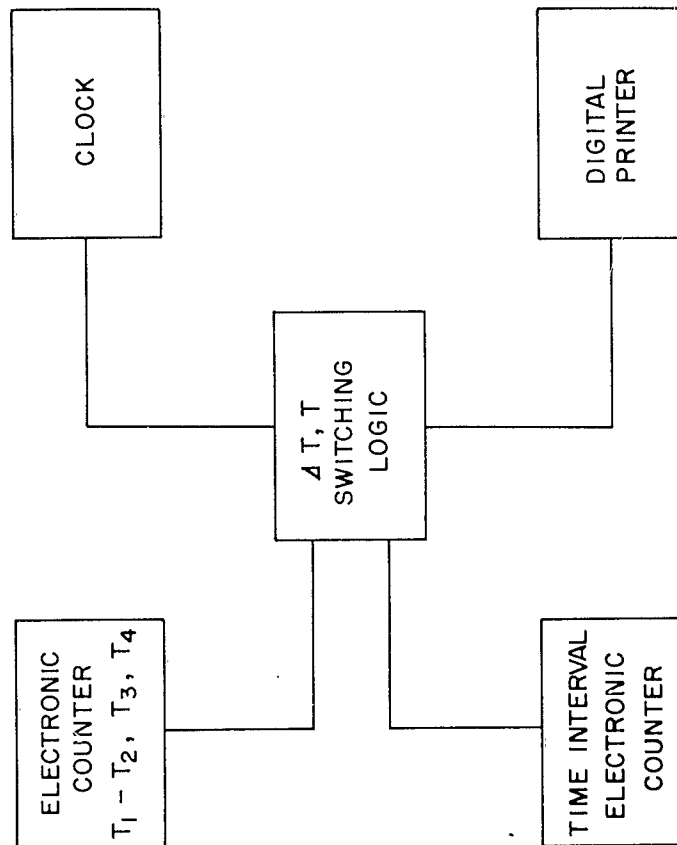
FIG. 11 BLOCK DIAGRAM OF PRINTER DATA SYSTEM

SUBMARINES
USS BLENNY SS 324
USS HARDER SS 568

BLENNY

N

TIMES FAX

SURFACE FIRE CONTROL RADAR
(SAUFLEY)

RUN B-16
1" = 1000 YDS
16 NOV 60

HARDER
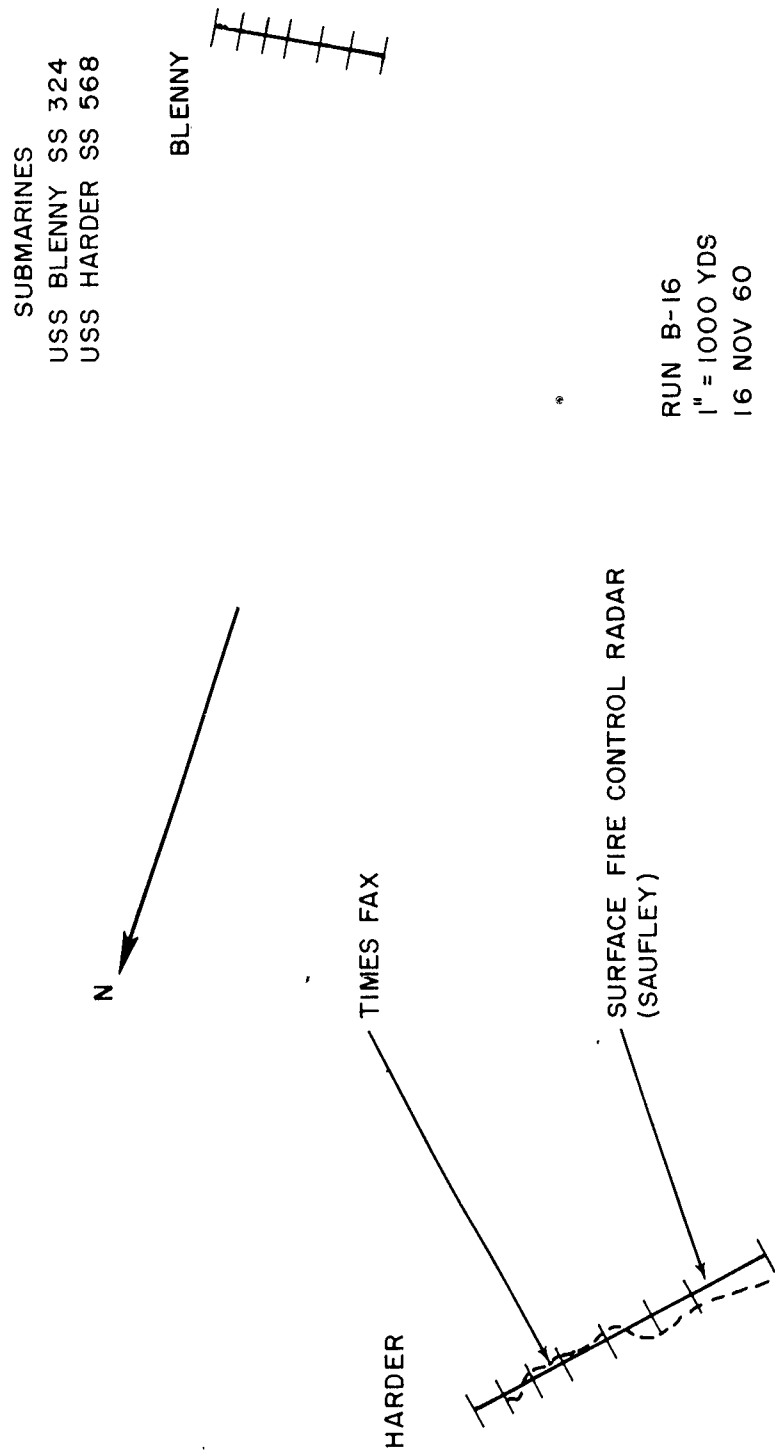
FIG. 12 TIMES FAX SYSTEM AND SURFACE CONTROL
(RADAR) RANGE COMPARISON-RUN

SUBMARINES
USS BLENNY SS 324
USS HARDER SS 568

RUN C-15
1" = 1000 YDS
17 NOV 60

BLENNY

N

SURFACE FIRE CONTROL RADAR
(SAUFLEY)

TIMES FAX

HARDER
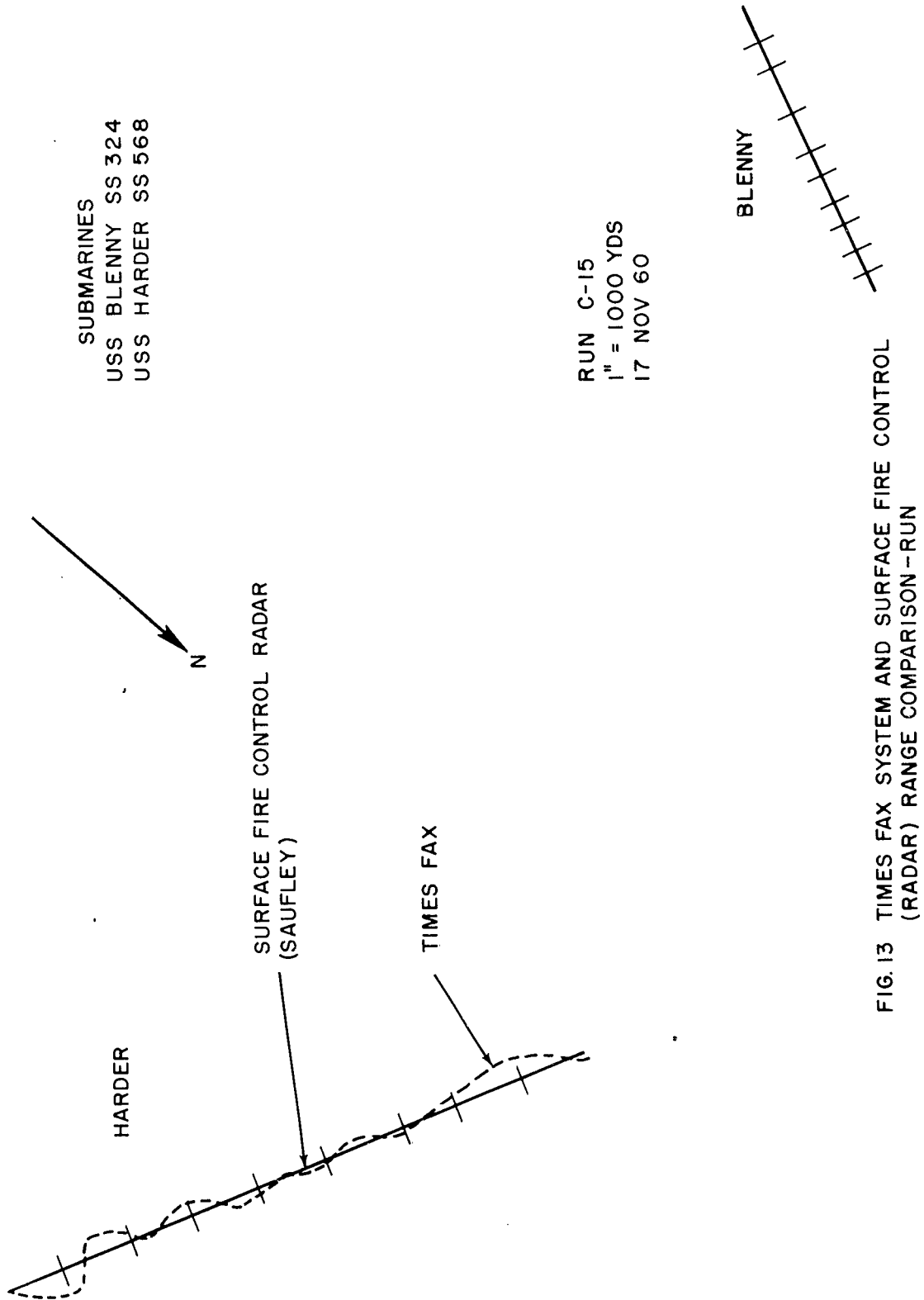
FIG. 13 TIMES FAX SYSTEM AND SURFACE FIRE CONTROL
(RADAR) RANGE COMPARISON-RUN

ASSUMING A 14 DB S/N RATIO, SOUND INTENSITY LEVEL
OF 90 DB/μB AT ONE METER AND A HYDROPHONE
SENSITIVITY OF -80 DB RELATIVE TO 1 VOLT TO 1 μB.
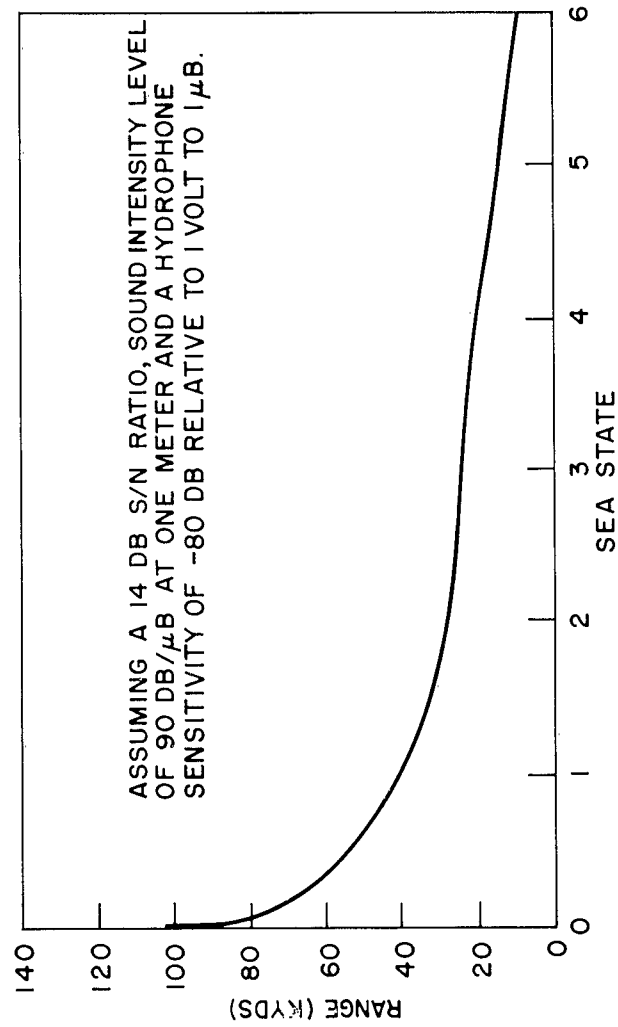
FIG. 14 ESTIMATED MAXIMUM TIMES FAX RANGE FOR
VARIOUS SEA STATES

APPENDIX A

GENERAL SPECIFICATIONS FOR QUARTZ
CRYSTAL OSCILLATOR

Stability

A-1. The stability should be five parts in 10^{10} per day or better. Short term stability should be one part in 10^{10} averaged over one-second intervals.

Standby Operation

A-2. In the event of power line failure, the crystal oscillator should be able to operate for extended periods from standby batteries.

Environmental Tests

A-3. The Quartz Oscillator is required to pass the following military environmental specifications:

a. Temperature - MIL-E-16400C, Class 4, paragraph 4.6.7 (non-operating test limits - -40°C to +60°C)

b. Vibration - MIL-E-16400C, paragraph 4.6.14

c. Inclination - MIL-E-4970A, paragraph 4.12.6 Procedure IV, Category "D"

Output Frequencies

A-4. The output frequency requirements are as follows:

a. A one megacycle sine wave measuring one volt across 50 ohms

b. A 100 kc sine wave measuring one volt across 50 ohms

c. A 100 kc sine wave of sufficient level to drive a frequency divider

Harmonic Distortion

A-5. The harmonic distortion should be 40 db or better below rated output. The non-harmonically related output should be 80 db or better below rated output.

Frequency Adjustment

A-6. A coarse adjustment is required with range of approximately 1 part in 10^6. A fine adjustment is required with range of approximately 600 parts in 10^{10}.

Monitor Meter

A-7. A front-panel monitor meter is required to monitor by selector switch the following:

    a. Supply voltage

    b. Oscillator voltage

    c. Inner oven current

    d. Outer oven current

    e. 1 mc output

    f. 100 kc output

Weight

A-8. The weight should be approximately 18 pounds.

Power Requirements

A-9. The power requirement required is 22 to 30 volts DC with the positive common to ground.

Size

A-10. The chassis should be approximately 17 inches by 12 inches by 5 inches. The front panel should be 19 inches long for rack mounting.

APPENDIX B

GENERAL SPECIFICATIONS FOR THE CHRONOMETER
(FREQUENCY DIVIDER AND CLOCK)

Input Frequency

B-1. The input frequency required is 100 kc.

Input Voltage

B-2. The input voltage required is from 0.5 to 5
volts rms.

Input Impedance

B-3. The input impedance required is 300 ohms nominal.

Auxiliary Output

B-4. Auxiliary outputs should be supplied for fre-
quencies of 1 kc, 100 cps and 10 cps. The voltage level
should be 0.25 volt rms, measured across a source imped-
ance of 1,200 ohms. Front panel BNC connectors are required.

Tick Pulse Outputs

	Rear BNC	Front BNC
Pulse Rate	1 pps	1 pps
Amplitude	+10V, Min.*	-10V, Min.*
Rise Time	2 μs Max.	2 μs Max.
Duration	20 μs Min.	20 μs Min.
Jitter	1 μs Max.	1 μs Max.
Min. Recom-mended Load Impedance	4.7 k ohms Min. shunted by 200 pf Max.	1 meg. Min. shunted by 100 pf Max.

Pulse Outputs	Positive	Positive
Pulse Rate	1 pps	1000 pps
Amplitude	+4V Min. open circuit +2V Min. across 50	+4V Min.
Rise Time	1 μs Max.	2 μs Min.

Frequency Divider

B-5. The frequency divider should be started manually. It should be of the regenerative type, and it should have a fail-safe feature.

Transient Effects

B-6. The frequency divider should not gain or lose time for the following:

  a. A ±300 volt step function on 100 kc input

  b. A 0 to 50 volt pulse or a 0 to 500 pps or 1 to 10 μs duration on 100 kc input

  c. A ±4 volt step in 26 VDC input

Clock Mechanism

B-7. The clock mechanism should have a 24-hour dial; a minute hand adjustable in one minute steps, second hand continuously adjustable. Starting should be manual.

Monitor Meter

B-8. Ruggedized meter and selector switch on front panel for checking supply voltage, divider operation (100 kc, 10 kc, 1 kc) and total clock current.

Power Required

B-9. Positive grounded 22 to 30 VDC, approximately 2 watts power dissipation.

APPENDIX C

A TRANSISTORIZED 300 WATT
1.066 kc POWER AMPLIFIER

Introduction

C-1. The transistorized power amplifier described
herein was designed and constructed for the purpose of
powering the Naval Research Laboratory's λM-3B underwater
acoustic transducer. The power amplifier was designed
using present state of the art techniques.

Description

C-2. The power amplifier integrates five basic cir-
cuits into a system. The basic circuits are a keying stage,
a tuned oscillator, a buffer stage, a driver stage and an
output stage. The integrated system circuit schematic is
presented in Figure C-1. The basic systems are as follows:

a. Keyer Circuit - The keyer uses a 2N174 tran-
sistor (Q2) for a switch. The transistor (off-on) state is
controlled by either the Times Fax chronometer relay contacts
or is controlled manually with a push-button switch that is
in series with the chronometer relay contacts. This switch
connects the base contact through a limiting resistor to
ground. Turning the keyer stage on will apply power to the
driver stage.

b. Oscillator Circuit - The oscillator consists
of a two stage amplifier with positive feedback. The fre-
quency of oscillation is determined by a tuned circuit
appearing in the collector circuit of the first transistor.
A Zener Diode is used as a power supply voltage regulator to
improve the frequency stability.

c. Buffer Circuit - The buffer stage is used as
a signal amplifier and also to provide impedance isolation
of the oscillator stage from the output stages. It consists
of an emitter follower followed by a grounded emitter ampli-
fier. The collector of the grounded emitter amplifier is
tuned by T2; a high Q, low impedance tuned circuit. Diode
CR2 and C1 serve as a power supply filter for the buffer
stage. This filter is necessary because the supply voltage

FIG. C-1 POWER AMPLIFIER

will drop when the amplifier is turned on through the keyer stage. Both the buffer stage and the oscillator stage operate continuously, as opposed to the driver and output stages, which only operate when the keyer is on.

     d. The Driver Stage - The driver stage is turned on by the keyer whenever an output pulse is desired. The driver stage consists of a class C grounded emitter amplifier Q1. Transformer T3 forms the tuned circuit for this stage. The windings of this transformer are applied by twisting four strands of Formvar insulated No. 16 AWG copper wire together and winding on 34 turns. Two of these strands are then tapped to obtain the proper turns ratio. This winding technique is utilized in order to minimize the leakage inductance between the several windings. The air gap of this transformer must be adjusted to make the transformer resonate with capacitors C2, C3, and C4 to a frequency of 1066 cps.

     e. The Power Output Stage - The necessary power output is achieved by employing four transistors in a push-pull, parallel circuit. These transistors are operated in essentially a class B manner. A grounded collector config-uration is used to assure the coolest possible operation of the transistors. The four resistors R1 and two transformers T5 are used to cause the transistors to share the load equally. Diode CR1 is a bias device to prevent thermal runaway. The output transformer has several different secondary windings to accommodate a variety of load impedances. Capacitors C5, C6, C7 and C8 are used as power factor correction devices since the transducer does not represent a purely resistive load. In addition, these capacitors provide a technique for coupling both the amplifier and the transducer polarizing supply to the transducer. In the present application capac-itors C5 and C6 are not used. The meter M1 is a wattmeter which is an aid in establishing proper polarizing current for the transducer during the initial adjustments.

    C-3. The transmitter was assembled on a heavy copper chassis using conventional assembly methods. The chassis serves as a heat sink for the transistor dissipation. No additional cooling technique is required for this applica-tion because the pulse duty cycle is quite low.

    C-4. Figure C-2 is a circuit diagram of the DC power supply used to operate this amplifier. It consists of a 28V 5 ampere hour storage battery with an automatic battery charging circuit. This power supply design presupposes that the amplifier will be operated in a pulse manner with a low duty cycle. Continuous operation of the amplifier will dis-charge the battery in about ten minutes.

FIG. C-2   SCHEMATIC WIRING DIAGRAM OF BATTERY SUPPLY, CHARGER AND
POLARIZING SUPPLY COMBINATION

C-5. The amplifier total efficiency is about 70 percent. The keying circuit produces good rise time for the output pulse with full output achieved within about two cycles of the carrier. The output waveform is nearly sinusoidal; however, it is somewhat dependent upon the power factor of the load.

C-6. To handle the power requirements, paralleled transistor circuits are used in each half of the push-pull class B power amplifiers. To insure that each transistor shares the current load equally, an equalizer inductor has been connected in series with the collector of each transistor. Any one of the two transistors per section may control the collector current by saturating the magnetic core.

C-7. The secondary of the power output transformer has four windings. Combinations of the windings will give impedance matching from 8.33 ohms to a maximum of 208 ohms. Also, output voltages varying from 50 to 250 may be obtained. The components for the power amplifier are standard commercial items. The transformer data is presented in Figure C-1. The DC supply for the power amplifier presented in Figure C-1 was designed for pulse operation. Any extended CW operation with this supply will degrade the power output to something less than maximum power.

APPENDIX D

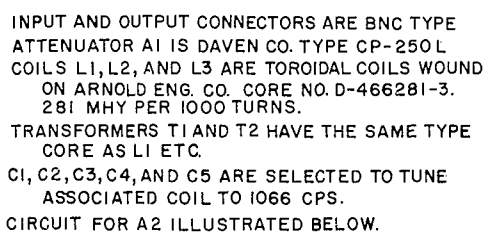DESIGN DETAILS OF THE TIMES FAX RECEIVER

D-1. The principal function of the Times Fax receiver
is to amplify the Times Fax signals as received by the sonar
and to recognize the signal pulse the instant it arrives.
When signal pulse recognition occurs, the receiver generates
an output pulse that stops the time interval counter. The
signal output from the sonar receiver contains ship's self
noise and sea state noise. For long ranges, the Times Fax
acoustic pulse will become the same order of magnitude as
the noise.and, hence, the receiver design problem becomes
the conventional problem of detecting signals in the pres-
ence of noise. The technique used to discriminate against
the noise was to make the receiver sharply tuned to the trans-
mitted pulse carrier frequency (i.e., 1066 cps). In order to
allow for a nominal amount of frequency misalignment between
transmitter frequency and receiver frequency, apparent fre-
quency shift due to doppler effects, and to provide a reason-
ably fast rise time; the receiver bandwidth was chosen to be
50 cps centered at 1066 cps.

D-2. It is to be expected that the ambient noise level
at the receiver input will vary due to changing sea state or
due to changed operation of the tracking ship. Therefore,
it is necessary that the receiver have some type of automatic
gain control (AGC) feature to provide proper operation in
spite of the varying input noise level.

D-3. Receiver design considerations relating the signal-
to-noise ratio for expected signals are as follows: The
receiver input signal due to the acoustic noise may be approx-
imated as a broad band noise voltage with a Gaussian amplitude
distribution. If the effect of passing this signal through a
band pass filter centered at a frequency of 1066 cps and having
a bandwidth.of 50 cps is considered, the signal passing out of
the filter will have a random amplitude variation. Analysis
will show that it is quite unlikely that in a period of a
minute the instantaneous amplitude will be more than five
times the rms noise voltage. The probability of the instan-
taneous amplitude exceeding four times the rms noise voltage
is considerably higher. These considerations lead to the
conclusion that the receiver should be designed to recognize
pulses that exceed five times the rms value of the noise
within the pass band of the receiver and ignore signals of
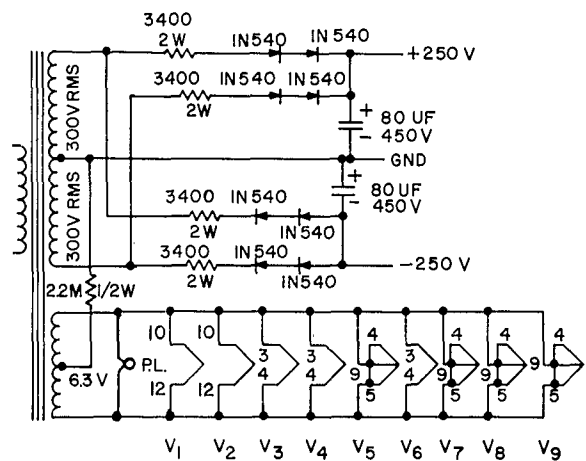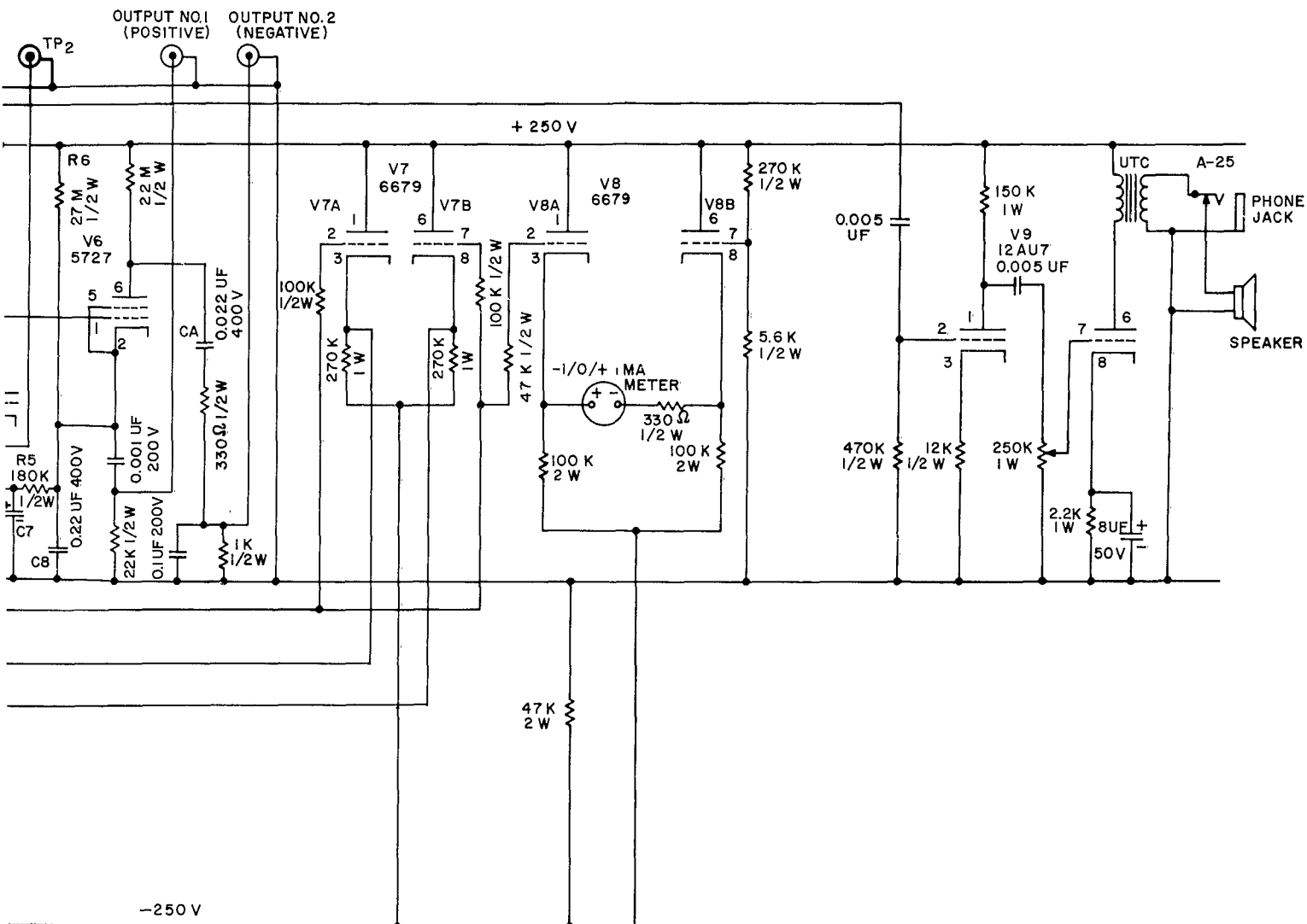lesser amplitude.

D-4. The above discussion points out the principal
design considerations for the receiver. It is to have a
bandwidth of 50 cps. The center frequency is to be 1066
cps. It is to have an AGC feature. It is to have a pulse
signal recognition threshold approximately five times the
rms noise level. It was assumed that the signals avail-
able from the sonar to be used as the receiver input signal
would be between 1 millivolt and 10 volts. The initial
design provided for these features. In the course of using
this receiver, it was ascertained that several additional
features were desirable and these were incorporated as add-on
modifications to the initial design. In reference to Figure
D-1, the circuit diagram, the initial design consisted of
vacuum tube stages V3, V4, V5, V6, V7 and the associated
components. The first modification consisted of adding a
meter to indicate the average noise level at the input to
the receiver. This modification consisted of vacuum tube
stage V8, associated components, and attenuator A2. It
was soon determined that under some circumstances the input
level was less than had been anticipated; hence, a preampli-
fier of vacuum tube stages V1 and V2 was added. The last
modification consisted of adding an audio amplifier, stage
V9, and a speaker as an aid in the adjustment and operation
of the Times Fax equipment. The net result of these several
stages of modification is a design that is somewhat different
than would have been obtained had all of these features been
considered at the outset. For example, the two attenuators
A1 and A2 both perform essentially the same function and one
would be sufficient but both, however, exist in the equipment
and, hence, appear on the circuit diagram.

D-5. A detailed description of the circuit operation
follows: The band pass filter function is provided by coils
T1, L1, L2, and L3 with the associated capacitors and resis-
tors. Coils T1 and L1 in conjunction with C1, C2, and R1
form a double tuned circuit of the type commonly used in
radio broadcast receivers. Reference (a) contains an excel-
lent analysis of this circuit. The analysis will not be
repeated. It is sufficient to say that this circuit is
based on an equal "Q" design with a value of 28 for Q.
Resistor R1 was chosen to provide proper primary loading.
No secondary loading resistor was required. Coils T2 and
L3 with associated capacitors are based upon the same design,
however, the impedance level is somewhat different due to
the specific location in the circuit. Resistor R2 was
selected to provide proper loading for L3. In this instance
no primary loading resistor was required. Capacitors C1,
C2, C4, and C5 must be selected to resonate their associated
coils at exactly 1066 cps. Coil L2 with capacitor C3 and

INPUT AND OUTPUT CONNECTORS ARE BNC TYPE
ATTENUATOR A1 IS DAVEN CO. TYPE CP-250L
COILS L1, L2, AND L3 ARE TOROIDAL COILS WOUND
  ON ARNOLD ENG. CO. CORE NO. D-466281-3.
  281 MHY PER 1000 TURNS.
TRANSFORMERS T1 AND T2 HAVE THE SAME TYPE
  CORE AS L1 ETC.
C1, C2, C3, C4, AND C5 ARE SELECTED TO TUNE
  ASSOCIATED COIL TO 1066 CPS.
CIRCUIT FOR A2 ILLUSTRATED BELOW.

APPROX. 5DB PER STEP

FIG. D-1 SCHEMATIC WIRING DIAGRAM OF TIMES FAX RECEIVER

FAX RECEIVER

OUTPUT NO.1 (POSITIVE) OUTPUT NO.2 (NEGATIVE)

TP1 TP2

+250 V

−250 V

V3 6662
V4 6662
V5 6679
V5A V5B
V6 5727
V7 6679
V7A V7B
V8 6679
V8A V8B

10K 1W
47K 1W
10K 1W
20UF 450V
L2 2000T #36
0.022 UF
0.01 UF 400V
C4 20 UF 450V
0.022 UF
T2 2000T #36
195T #36
L3 5500T #32
R6 27 M 1/2 W
2.2 M 1/2 W
1M 1/2 W
220K 1/2 W
R2 2.7M 1/2 W
0.003 UF C5
R4 100K 1/2 W
80 UF 450V C6
47 K 1/2 W
R7 1M 1/2 W
80UF 450V C7
R5 180K 1/2 W
0.22 UF 400V
0.001 UF 200V
C8
CA
0.022 UF 400 V
330 Ω 1/2W
22K 1/2 W
0.1UF 200V
1K 1/2 W
100K 1/2W
270 K 1W
270 K 1W
100 K 1/2 W
47 K 1/2 W
−1/0/+ 1 MA METER
330 Ω 1/2 W
100 K 2W
100 K 2W
270 K 1/2 W
0.005 UF
5.6 K 1/2 W
470K 1/2 W

82 K 1/2 W R1
20 UF 450 V
IN 540
20 UF 450 V
IN 540
IN 716 12V Z.D.
1.5 K 1/2 W
IN 716 12V Z.D.
47 K 2W
47 K 2W
47 K 2W
47 K 2W

3400 2W IN540 IN 540 +250 V
3400 2W IN 540 IN 540
+ 80 UF − 450V
GND
+ 80 UF 450V
3400 2W IN 540 IN540
3400 2W IN 540 IN540 −250 V

1A
115 V 60 CPS
SW
THORDARSON TYPE T 22 R05
300V RMS
300V RMS
300V RMS
300V RMS
2.2M 1/2W
6.3 V
P.L.

10 10 3 3 4 4 4 4
12 12 3/4 3/4 9 3/4 9 9 9
5 5 5 5 5

V1 V2 V3 V4 V5 V6 V7 V8 V9

2

TP2

OUTPUT NO.1 (POSITIVE) OUTPUT NO.2 (NEGATIVE)

+ 250 V

R6
27 M 1/2 W
2.2 M 1/2 W

V6
5727

V7 6679
V7A   V7B
V8 6679
V8A   V8B

270 K 1/2 W

150 K 1 W

UTC   A-25

V9 12AU7

PHONE JACK

0.022 UF 400 V
CA
100K 1/2W
0.005 UF

SPEAKER

R5 180K 1/2 W

C7

C8

0.22 UF 400V

0.001 UF 200 V

330 Ω 1/2 W

270 K 1 W

270 K 1 W

100 K 1/2 W

47 K 1/2 W

-1/0/+ 1 MA METER

330 Ω 1/2 W

100 K 1/2W

5.6 K 1/2 W

0.005 UF

0.1 UF 200V

22K 1/2 W

1 K 1/2 W

100 K 2 W

100 K 2 W

470K 1/2W

12K 1/2 W

250K 1 W

2.2K 1W

8UF 50V

47 K 2 W

−250 V

3400 2W   IN540   IN540   +250 V

300 V RMS   300 V RMS

3400 2W   IN540   IN540

80 UF 450V

GND

80 UF 450V

300 V RMS

3400 2W   IN540   IN540   −250 V

3400 2W   IN540   IN540

2.2M 1/2W

6.3 V   P.L.

10   10   3   3   4   4   4   4
12   12   4   4   9   9   9   9
           9   9   5   5   5   5

V1   V2   V3   V4   V5   V6   V7   V8   V9

3

resistor R3 form a single tuned circuit also described in
reference (a). The Q in this case was chosen to be 10,
thus, most of the filtering action is provided by the double
tuned circuits. Capacitor C3 is selected to resonate coil
L2 at 1066 cps.

D-6. The signal amplification is accomplished by vacuum
tube stages V1, V2, V3, and V4. The preamplifier stages V1
and V2 are conventional resistance-capacitance coupled stages.
The vacuum tube type 7586 was chosen for its excellent low
noise characteristics. The preamplifier circuits can provide
a gain up to approximately 54 db depending upon the setting
of attenuator A1. Vacuum tube stages V3 and V4 are designed
to match a remote cutoff pentode. The AGC action is accom-
plished in these stages.

D-7. Vacuum tube stage V5A serves a dual function: as
an infinite impedance detector and a cathode follower for
positive going signals at its grid terminal. The signal at
the grid will be an AC signal with an amplitude of about 20V
rms. The signal at the cathode will follow only the positive
portions of the grid signal, hence, the signal at test point
TP1 will appear as a series of half sine pulses. This signal
will have a DC component which is a function of signal ampli-
tude. The DC component is passed through the filter R4-C6 and
this is the signal used for the automatic gain control opera-
.tion. The term signal as used here refers to the voltages at
the several points. The voltages are due mostly to the acous-
tic noise present at the hydrophone due to the low duty cycle
of the Times Fax transmitter. This is not to be interpreted
as implying the signal-to-noise ratio to be poor at this stage,
but rather that the function of this stage is determined over
an interval of several seconds and actual pulse signal lasts
for only about 1/20 of a second. The DC component of voltage
is, therefore, due mainly to the acoustic noise. In precise
terms, the signal at TP1 is intended to be a replica of the
instantaneous grid signal. The voltage across capacitor C6
is intended to be proportional to the average value of the
envelope of the pulse signal plus the voltage due to the
acoustic noise.

D-8. Vacuum tube stage V5B is also an infinite impedance
detector, however, this stage determines the peak value of the
signal plus noise. Presumably the peak value will be due to
the signal pulse as it is expected that the signal will be at
least five times larger than the rms noise. The peak value of
the instantaneous signal envelope appears across C7. The
build-up time of this voltage is about 30 milliseconds due to
the limited transconductance of tube V5B. This is a desirable

condition because this voltage is used as a hold-off bias for the pulse detector.

D-9. The thyratron V6 is used as the pulse detector. The instantaneous positive portion of the signal plus noise is applied to the grid. The cathode is biased by a voltage derived from the last previous pulse signal. The time constant of R7-C7 has been selected to allow this bias to decrease to about 80 percent of the last previous signal amplitude. This is essential because the amplitude of successive signal pulses cannot be expected to always be identical, and some provision must be made for intervals of decreasing signal level. There is, in addition, a fixed bias for V6 which is obtained through R5, R6, and R7. This is necessary because of the static characteristics of V6. When the instantaneous grid signal of V6 exceeds approximately 80 percent of the last previous pulse signal, V6 will conduct and discharge C9. A positive going output signal will appear at output terminal No. 1, and a negative going output signal will appear at output terminal No. 2. Output signals of both polarities are made available to accommodate several types of counters and period readers.

D-10. The automatic gain control function is accomplished by applying the voltage that appears across C6 to the cathodes of V3 and V4. This voltage is routed through both halves of V7 connected as cathode followers for impedance matching purposes. The AGC signal is applied to the cathodes of V3 and V4 rather than to the grids, which is the more conventional technique. This is done to minimize the problem of preventing amplifier oscillations through common impedance coupling.

D-11. The meter circuit, V8, is calibrated in decibels after the receiver is constructed. It provides a relative measure of noise level. This feature is most useful during a specific test run as it provides a relative indication of the noise conditions.

D-12. The audio amplifier and power supply are conventional in design. The audio amplifier is useful in establishing initial contact during the course of a test. The incoming pulse signal can be easily detected by ear even in the presence of considerable local noise.

D-13. The receiver was constructed using conventional techniques. The tuned circuits were placed in shielded enclosures to prevent oscillations. Harmonics of the 60 cps power frequency also tend to cause noise like signals within the pass band of the receiver and some shielding must be provided to eliminate this problem.

D-14. The operation of the receiver is satisfactory, in general; however, some specific features need further development effort. The minimum input signal level is approximately 10 microvolts rms. The major objectional feature is in the area of response to noise pulses. When the signal-to-noise ratio is low, the probability of generating false output signals tends to be much higher than anticipated by analysis. The reason for this is not wholly understood but several areas are suspect. Gaussian noise distribution was originally assumed, whereas it is suspected that the actual acoustic noise present contains considerable impulse-type noise generated by the vessel carrying the Times Fax equipment. A second suspect area is the threshold detector. The threshold detector in conjunction with the AGC circuits are designed to recognize pulse signals or impulse-type noise whenever the instantaneous signal plus noise exceeds 80 percent of the last previous pulse. This action is modified by certain fixed biases in the threshold detector and is a function of the specific noise level at the detector. These are affected by the attenuator settings and the AGC circuit; hence, it is difficult to establish an optimum operating condition. It is believed that the threshold device should be designed to recognize pulse signals that exceed the noise by a fixed ratio regardless of the noise level. The present design is that for strong signals the threshold is only a function of signal. For weak signals, the threshold is a fixed voltage above the noise which is dependent upon AGC action and attenuator settings. It should be pointed out, however, that a laboratory test with a Gaussian noise source and simulated pulse signals at a signal-to-noise ratio of five produced no false output signals over an interval of 500 true input pulses.

D-15. Work is in progress, at present, to develop a receiver that will have a stronger AGC action and a threshold device that is only a function of signal to noise ratio. It is expected that some additional discrimination against impulse-type noise can be obtained by disabling the receiver during those intervals when it is impossible to receive a true pulse signal. This is possible for any specific test because the range to be measured lies between certain previously known values.

References

(a) "Vacuum Tube Amplifiers" by Vally and Wallman, Radiation
     Laboratory, Series Vol. 18 published by McGraw-Hill Book
     Company

APPENDIX E

LOGIC PUNCH-OUT SYSTEM

Introduction

E-1. The Logic Punch-out System was designed to record the Times Fax ranges, real time, and time interval information. Therefore, the Punch-out System described herein includes the logic components required for the data outputs of the sonar system. The sonar system's logic requirements may be easily omitted or a similar system may be purchased commercially with the sonar system requirements omitted.

Purpose of System

E-2. The system is designed to record output from an electronic counter and a slave clock once per second. The system records by punching holes in a paper tape. The advantages of using paper tape are:

      a. The punch is physically small.

      b. Paper tape is widely available.

      c. Visual output checks can be made during operation.

      d. It is an incremental digitial recorder versus continuous punch-out.

General Explanation

E-3. Basically, the system punches data on a tape once every second, upon receipt of a signal from a chronometer. The data consists of three parts: 5 decimal digits from the monitoring electronic counter, 5 digits from the Times Fax counter, and 6 digits from a slave clock. The data output for any one second is referred to as a record. A typical record is shown in Figure E-1. The slave clock data provides a reference time count to aid in identification of the data. Once every ten seconds, on the count of either 8, 18, 28, 38, 48, or 58 seconds, the normal reading DT is replaced by a different reading T. The T is identified by a 4, 5, or 6 in
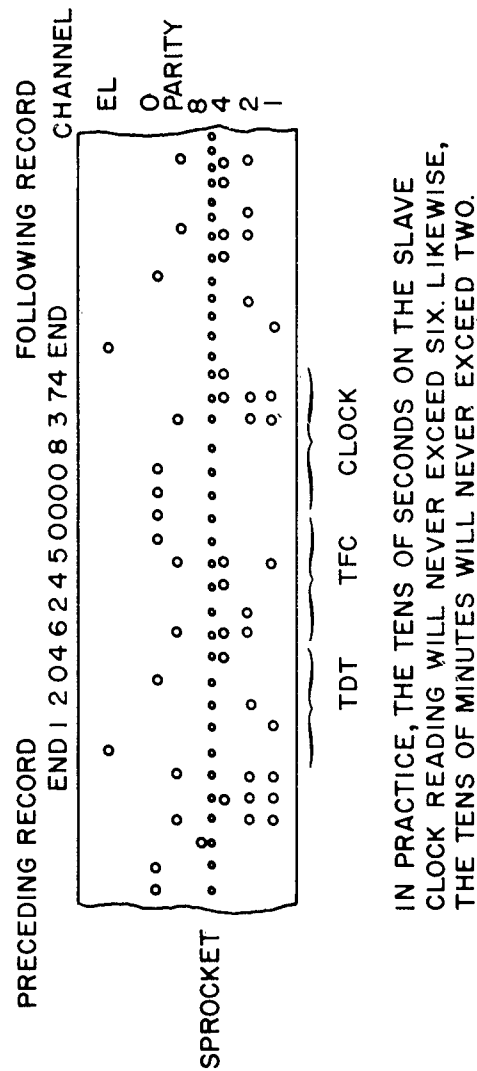
FIG.E-I TYPICAL TIMES FAX RECORD

IN PRACTICE, THE TENS OF SECONDS ON THE SLAVE
CLOCK READING WILL NEVER EXCEED SIX. LIKEWISE,
THE TENS OF MINUTES WILL NEVER EXCEED TWO.

the tens of hours digit of the preceding (7th second) record. The overall block diagram (Figure E-2) and the general explanation that follows describes the system.

E-4. The Chronometer provides accurate time signals to the slave clock and the two counters. T1, T2, T3, and T4 are the time interval or period functions that are monitored. The interval between T1 and T2 is defined as DT. The interval between T3 and T4 is defined as T. When the TDT Counter has stopped, it provides a -6 volt level to the Programmer. This level tells the Programmer that the counter is ready to be read out. The Times Fax Counter functions similarly.

E-5. The Programmer provides the following:

      a. The "Q" and "PF" pulses to read data into the Shift Registers.

      b. The Shift pulses which shift the Shift Register.

      c. The Reset pulses to reset the last stage of the Shift Register of each channel.

      d. The "Sprocket" and "End of Line" pulses to the Tape Punch.

      e. The "TDA" pulse, which is punched as the "4" bit of the tens of hours digit, is used to mark the T reading. The TDA pulse causes the switching from T1 - T2 to T3 - T4 for the 8th second reading. All of these pulses are synchronized.

E-6. "TDT" tells the Programmer when the seconds reading on the slave clock ends in 7. This information is used to set up "TDA".

E-7. The "Parity and Zero Generator" provides the zero pulse and the check pulse to the Tape Punch.

E-8. The Tape Punch translates the information pulses into holes in the paper tape.

E-9. There are four shift channels, one each for the 1, 2, 4, and 8 bits. They are identically parallel with respect to the shift pulses and the reset pulses.

E-10. There is also an "And" gate for each Shift Register bit which may be read as a logical "1". (Note that some bits will always be "0" since the slave clock counts seconds and minutes to 60 and hours to 24. These bits do not have
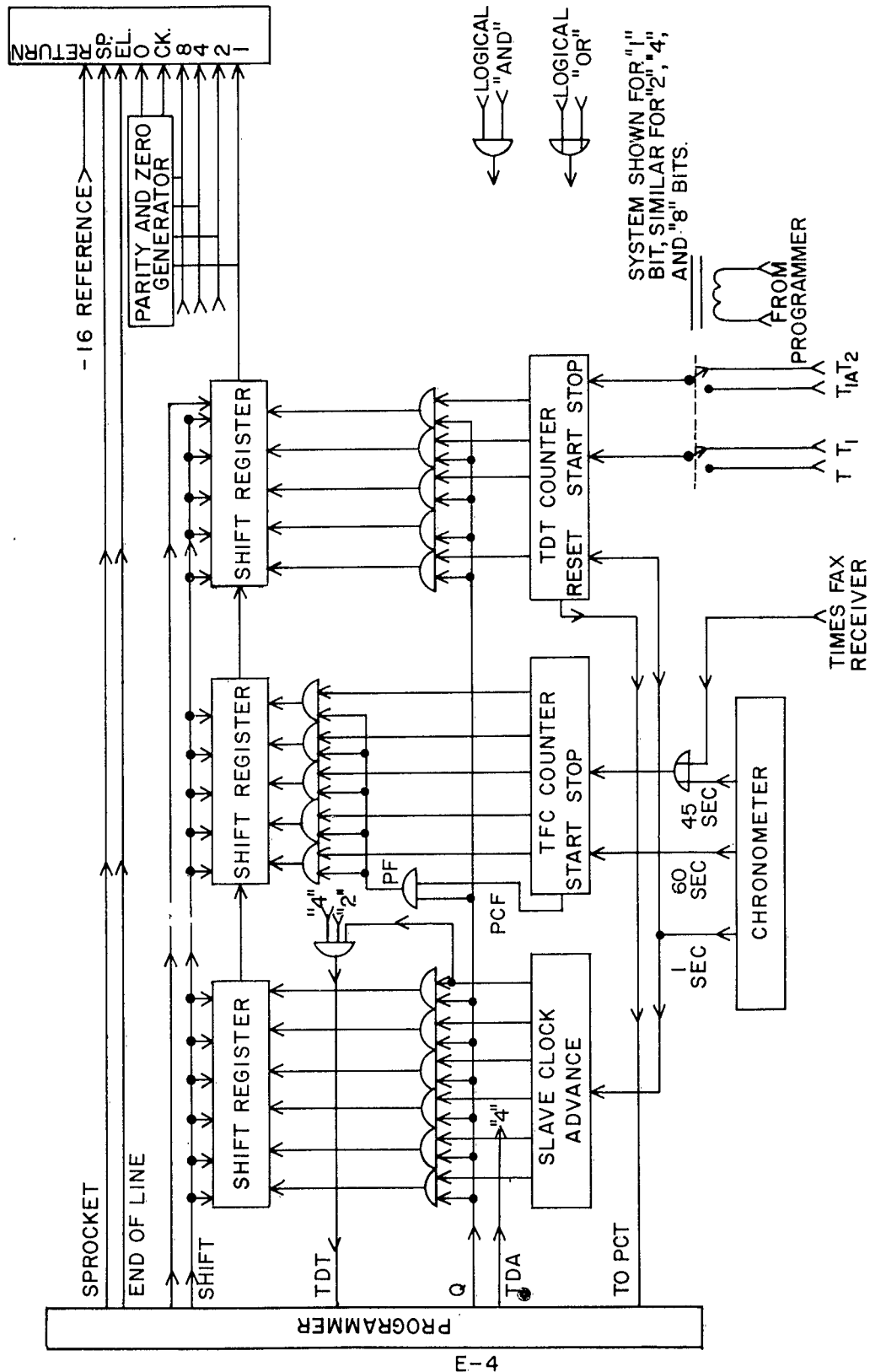
FIG. E-2 SIMPLIFIED DIAGRAM OF SYSTEM

corresponding "And" gates.) All the gates associated with
the TFC counter are connected in parallel to the "PF" pulse.
Similarly, the "Q" pulse is connected in parallel to the gates
for the Slave Clock and the TDT counter.

Details of the System

E-11. This section does not include either the programmer
or the punch.

Chronometer

E-12. This is an accurate temperature stabilized crystal
controlled clock which provides signals every second, every
45th second, and every 60th second.

TDT and Times Fax (TFC) Counters

E-13. These are 10 megacycle universal counter-timers,
which have been modified to increase the drive available to
external loads, and to permit resetting them by external
pulses. Under the present system, the TFC Counter resets
itself, while the chronometer supplies a reset pulse, once
a second, to the TDT Counter.

E-14. The TDT Counter is started and stopped by pulse
signals that are monitored (i.e., sonar). One reading is
taken each second. Normally, the counter is started by a
pulse T1 and stopped by a pulse T2, thus, measuring DT.
However, the inputs are switched in such a manner that, when
the seconds reading of the slave clock ends in 8, the TDT
Counter records the time interval between pulses T3 and T4,
thus, measuring T.

E-15. Switching of these pulse signals is accomplished
by having relay contacts transfer position at the time of
completion of a DT count while the slave clock is reading
seven seconds until completion of the next count.

E-16. The TFC Counter is started by a pulse from the
chronometer, precisely at the beginning of each minute. It
is allowed to run until a pulse is received from the Times
Fax receiver. If no such pulse is received, the chronometer
will stop the counter by a stop impulse 45 seconds later.

E-17. At the completion of a count in either the TDT
or TFC Counter, the data output lines for each bit will pre-
sent a nominal voltage level of -6V, if a "1" is present,
and 0 volts for a zero. Likewise, a negative voltage will
appear on the "print command" line for each counter, a short
time after counting has been completed. This negative voltage
will remain present until the corresponding counter is reset,
at which time it will drop to zero volts. The transition
from 0 to -6 volts on the TDT Counter's "print command" line
is sensed by the programmer to initiate a print cycle. If
such a transition is sensed on the "print command" line of
the TFC Counter at any time following the start of the previ-
ous print cycle, its data will be stored in the shift register
after completion of this cycle and will be printed along with
TDT and slave clock data during the next cycle, in the following
second. Otherwise, zeros will appear in the location reserved
for punching this information.

Slave Clock

E-18. This is a Digital Clock, which has been modified
to give greater output. This clock gives the time each
reading was made. It is synchronized to the chronometer
and advances its count by one second each time the chronometer
emits a "reset" pulse.

TDT Gate

E-19. This is a digital "flip flop" circuit which gives
an output when the "second" reading of the slave clock ends
in 7. The programmer uses this output to energize an input
relay to the TDT counter so the reading corresponding to the
next second is the interval from T3 to T4. See Figure E-3.

Shift Registers

E-20. Refer to Figure E-3 and Figure E-4. Each clock
or counter gives an output in Binary Coded Decimal format.
Thus, each digit has a "1", "2", "4", and "8" bit, which is
present only for certain digits. Each bit from the counter
goes to one input of a two-legged NAND gate. The other input
to each of the NAND gates is either the Q pulse (for data
recorded each second) or the PF pulse (for Times Fax data).
When either a Q or PF pulse appears at the input to the gate
while the other input is -6V, the data in the counter is trans-
ferred to the corresponding bit in the Shift Register, as indi-
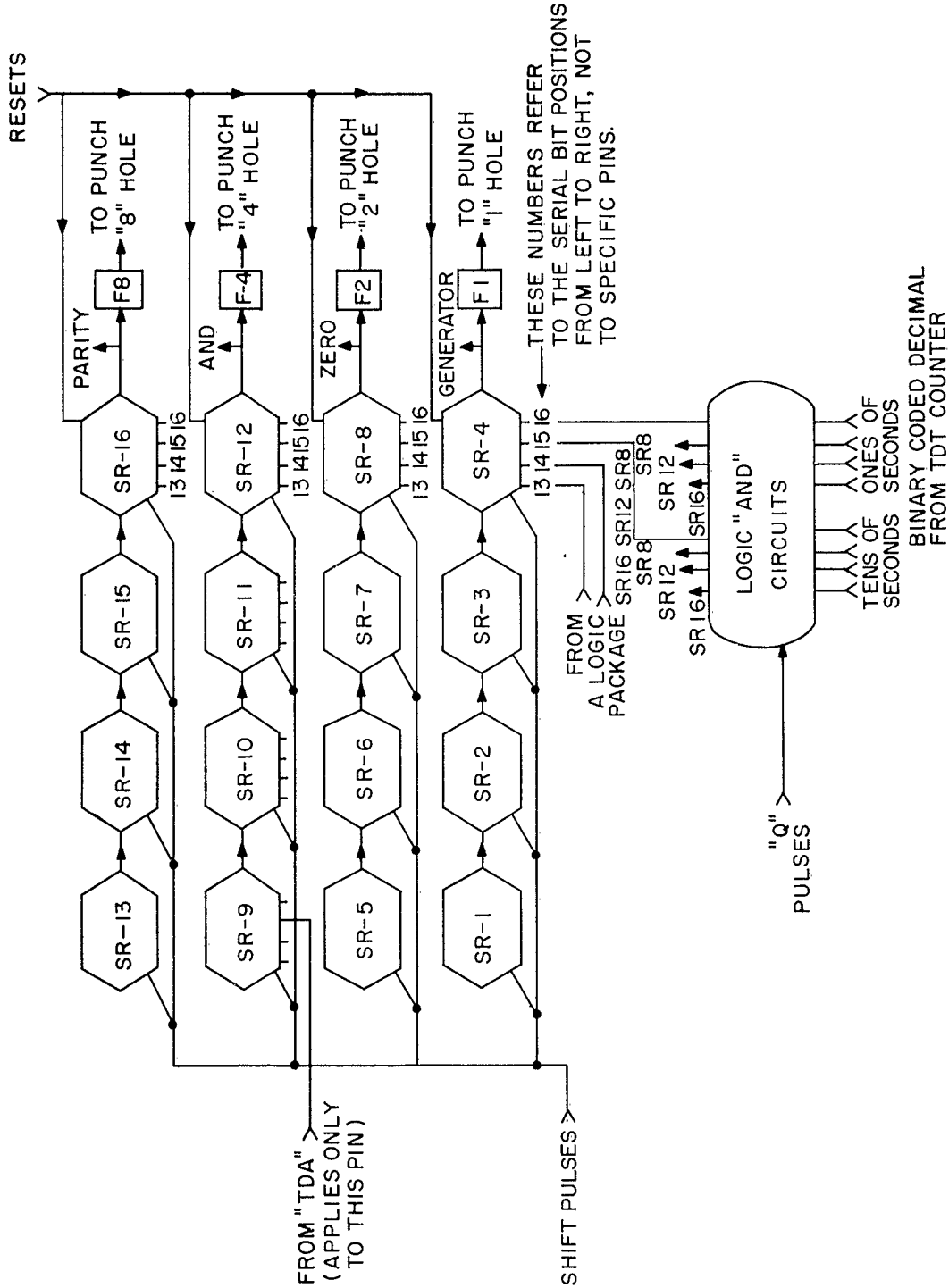cated in Figure E-2.

FIG. E-3 ARRANGEMENT OF THE SHIFT REGISTERS AND GATES, WITH TYPICAL DETAIL
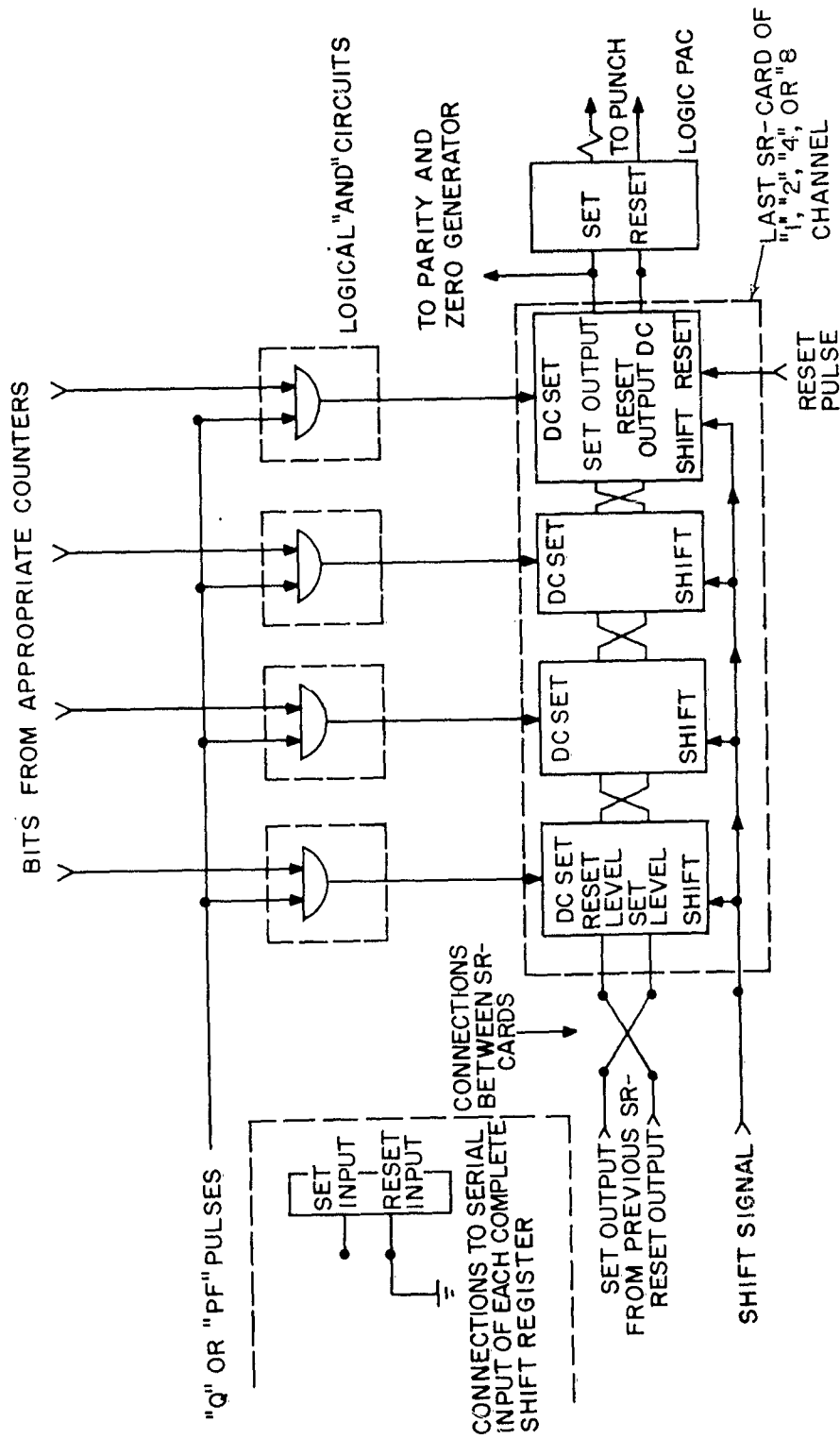
FIG. E-4 CONNECTION DETAIL OF TYPICAL LAST STAGE OF SHIFT REGISTER CHANNEL

E-21. There are four 16-stage shift registers, one each for the "1", "2", "4", and "8" bit of each digit. The registers are identical, except for the "TDA" and "TDT" connections noted in Figure E-3 and Figure E-2, respectively. Each shift register is actually made up of four serially cross-connected shift register cards, each of which is really a four-stage Shift Register. See Figure E-4. The set level input of the first stage of each channel's shift register is connected to a -6 volts, while the reset level is connected to 0 volts.

E-22. These fixed complementary serial inputs cause zero to be shifted into the first stage to replace data shifted out. Thus, after sixteen shift pulses the entire register is cleared without need for overall reset pulses. However, because the punch input electronics require pulses not less than 50 μs a reset pulse is required in order to generate a pulse that is compatible with the punch's input electronics. In addition, a similar "sprocket" pulse is required at the same time as the data to drive the punch.

E-23. The output of each channel's shift register drives a flip flop, the output of which is coupled through a dropping resistor into the punch. The resistor must drop the voltage from -16V to between -10V and -6V and is, thus, not very critical. The shift registers remain in any given state until they are switched.

TDA Signal

E-24. The "TDA" signal is obtained from the slave clock on the 7 second. This signal is then sent to the third stage of shift register 9. This is the "4" of the tens of hours reading from the slave clock and will cause it to indicate a 4, 5, or 6 on the tape, instead of 0, 1, or 2, respectively. This illegal reading indicates that on the following second the TDT counter is reading out T instead of ΔT. The TDA signal is on for almost a full second.

Parity Generator

E-25. This is a digital logic circuit which drives a logic "flip flop" whenever an even number of holes is present, i.e., on a 3, 5, 6, or 9. Therefore, the total number of holes across the paper strip should always be odd. The pulse sent to the punch for parity follows the shift pulse by 3 μs

to insure that its output corresponds to the data present after the shift has taken place.

Zero Generator

E-26. This Logic package provides a zero pulse, if the "1", "2", "4", and "8" are zero. This is sent also to the punch $3 \mu s$ after the shift pulse.

Programmer (See Figure E-5)

E-27. The programmer generates the load, shift, sprocket, reset and end of line pulses, in their proper sequence. It utilizes "dynamic" type logic, rather than the more conventional "static" type. Hence, unless one is familiar with this type of logic, it is difficult to describe its operation in any detail, and only a very general description of its operation is given here.

E-28. Upon receipt of a print command pulse from the counter which is read each second, a single pulse PT is generated, which is used to turn on a flip flop W. This flip flop enables the frequency dividers D11, D58, and D63 to operate, thus, providing output pulses at time intervals of approximately 11 x 58 x 63 microseconds, or about 25 times per second. These output pulses are used to generate shift pulses, SH, to the tape punch, and also count pulses into a binary counter C1-C5. The timing of the shift pulse is delayed so that a load pulse Q is generated on the first count in the counter and the shift pulse follows about 58 μs later. The SH pulse (see Figure E-6) is used to set flip flops RE1 and RE2, which are then reset about 58 μs later. The resulting waveform output of RE2 is used to provide the "sprocket" pulse to the punch. This must accompany each set of data inputs to the punch to cause it to punch the data presented to it. See Figure E-7.

E-29. The trailing edge of the RE1 pulse is used to generate a short duration pulse to reset the final stage of each of the shift registers, so that they will present the proper data to the punch electronics.

E-30. At the binary count of seventeen, gate EL passes a pulse which resets the binary counter C1-C5, and also resets the flip flop W, which then inhibits the frequency dividers and programming clock, thus, preventing any
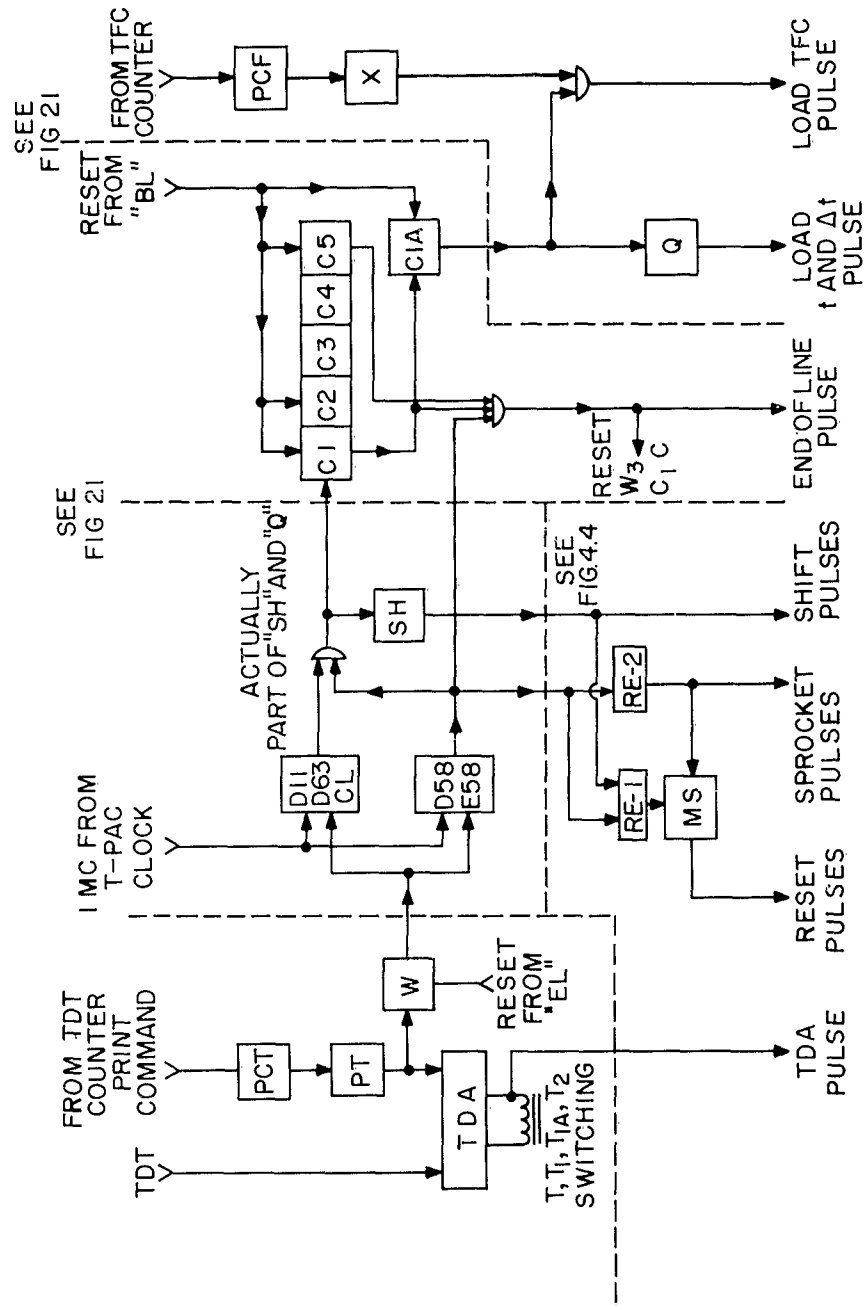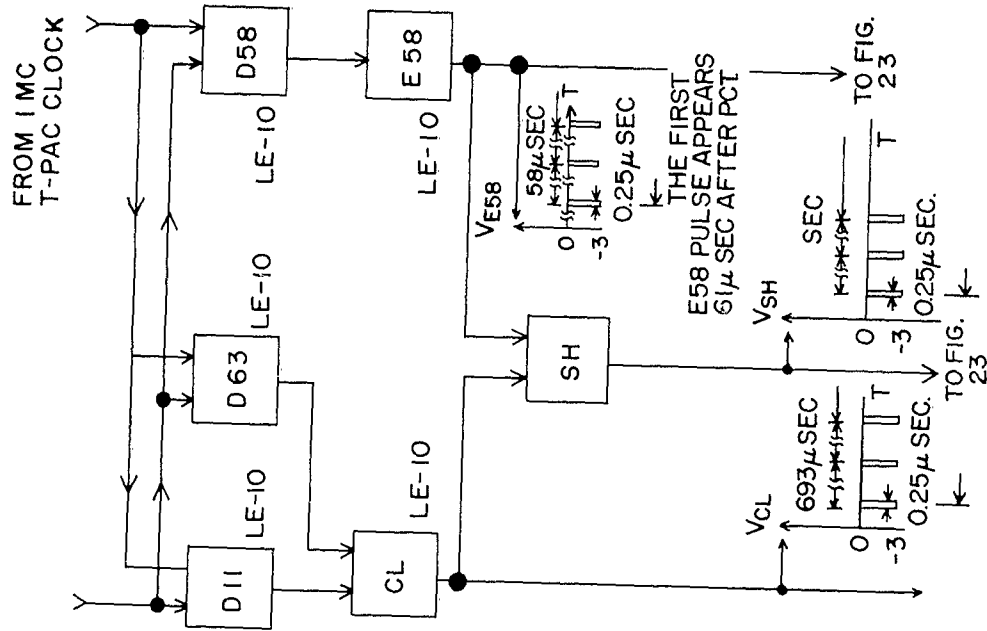
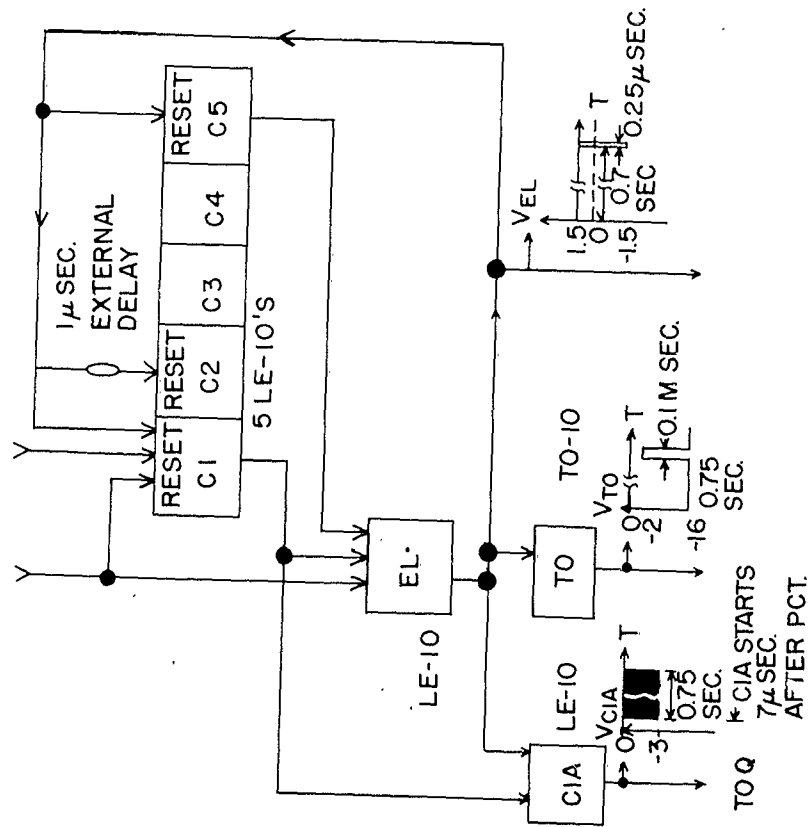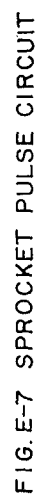FIG.E-5 PROGRAMMER-SIMPLIFIED DIAGRAM

FIG. E-6 SH PULSE CIRCUIT

FIG. E-7 SPROCKET PULSE CIRCUIT

more pulses from being counted until another print command is received. The output of EL is likewise used to reset a flip flop ClA, and to feed a one-shot TO. TO gives a 100 μs duration pulse to track 8 on the punch, to generate an end of line punch in that track, on the seventeenth pulse. See Figure E-6. ClA is then reset, and is ready to gate in another Q pulse at the beginning of the next cycle.

E-31. If a print command signal is received from the Times Fax counter, a single pulse is generated by TCF which sets flip flop X. This remains set so that on the next Q pulse, it is passed through gate Y, which resets X, and at the same time is shaped by other packages, as shown in Figure E-8, to generate the gating pulse SF, which loads the data into the register to be shifted out during the punch cycle.

E-32. In some cases more than one package is used to shape and supply load pulses, etc. This is done in order to limit the package loading to acceptable values or to provide correct voltage levels, and has no function in explaining the logical operation.
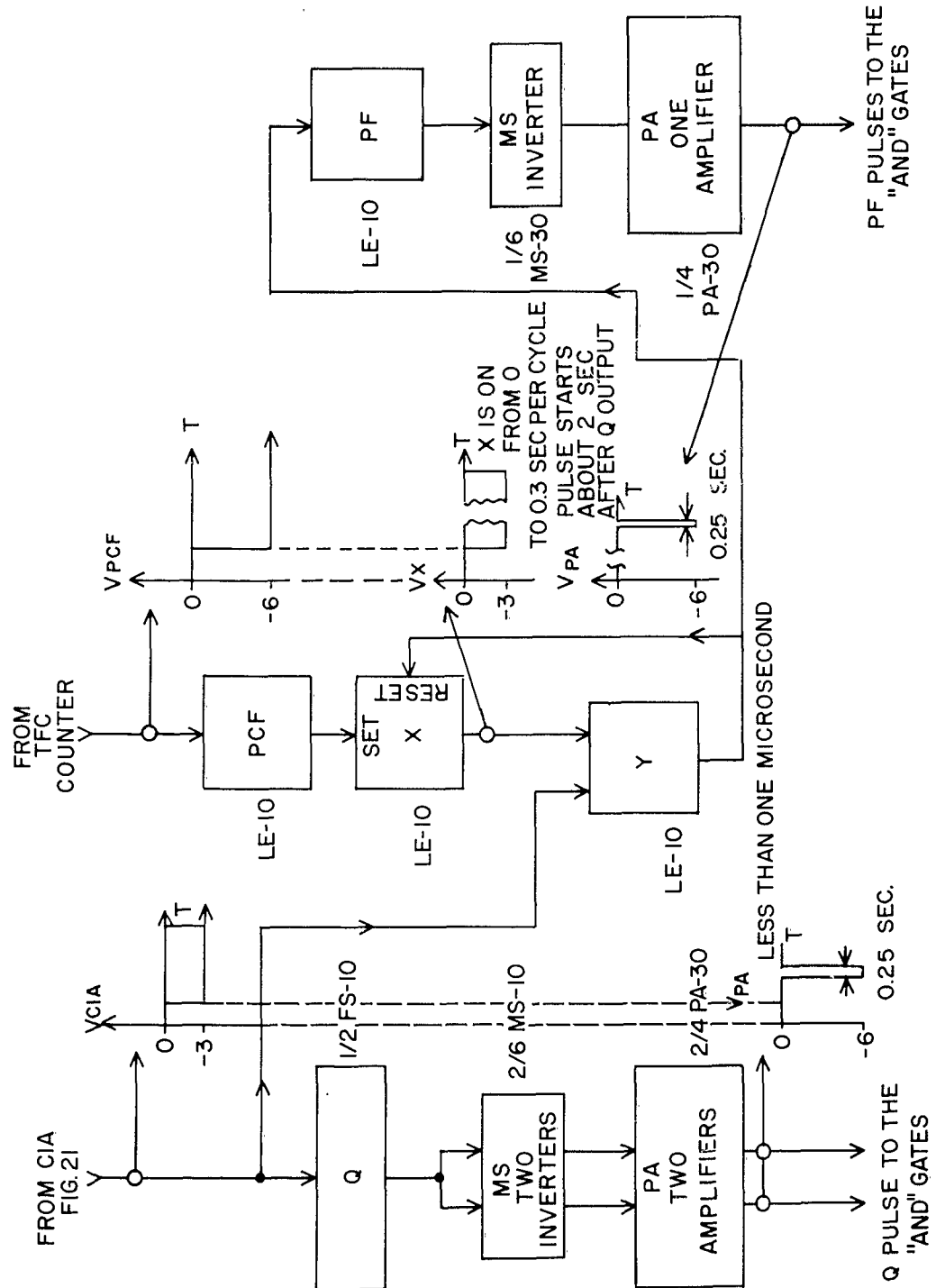
FIG.E-8 SHAPE PULSE CIRCUIT

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(NOL technical report 62-219)
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